Assessment of the Pt nanoparticle distribution on oxidized stainless steel surfaces by electrochemical techniques

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Application of platinum (Pt) nanoparticles for stress corrosion cracking (SCC) mitigation in boiling water reactor components, such as those manufactured from stainless steel, relies on their catalytic ability for the reduction of oxidizing species (O_2, H_2O_2) in the presence of excess H_2. This technology is referred to as noble metal chemical addition or NobleChem^{TM} and is being implemented in a number of boiling water reactor plants worldwide. $Na_2Pt(OH)_6$ solution is injected into the feed water which undergoes hydrolysis and condensation reactions to form Pt nanoparticles. The goal is to achieve homogeneous Pt surface coverage with a minimal quantity so as to protect the entire surface from SCC. The surface loadings (mass/area), size, as well as spatial distributions of these Pt nanoparticles directly affect their ability to attenuate SCC.

Electrochemical corrosion potential (ECP) and, for the first time, electrochemical impedance spectroscopy (EIS) measurements have been performed to correlate them with the Pt surface loadings as well as the spatial distribution of Pt particles. A series of AISI 304L stainless steel coupon specimens with varying Pt surface loadings and interparticle distances were produced and confirmed using high-resolution scanning electron microscopy. The ECPs were recorded in a simulated BWR environment (high-temperature, high-purity water at 280 °C and 90 bar) while the EIS measurements were conducted in electrolyte solution (e.g., Na_2SO_4 solution) at ambient pressure with temperatures of 25 as well as 70°C. Preliminary results revealed a variation of the EIS response depending on the amount of Pt present on the specimens, indicating that this method has the potential to act as a 'quality control' technique for assessing the Pt surface loading. Nevertheless, there seems to be a direct and better correlation of ECP values to the Pt interparticle distances as compared to that of Pt loadings. More investigations are currently being undertaken to further explore the suitability of the EIS technique as a tool to assess the quality of the Pt coverage with respect to catalytic activity und thus SCC mitigation.