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Corrosion of Cold-Spray Deposited Copper Coatings on Steel Substrates

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The proposed Canadian nuclear waste disposal canister consists of an inner cast iron vessel and an outer shell of copper to provide corrosion resistance. Various methods to manufacture the outer shell of these containers are being considered including processes such as cold spray and electrodeposition. Cold spray coating (CSC) is a high rate deposition process in which powder particles are accelerated to high velocity and, on impact, adhere to the substrate surface at a temperature that is below the melting temperature. The advantages of this technique are that the coating layer is rigid with an easily controlled thickness, and free from oxidation. [1, 2]

The purpose of this study is to provide a preliminary corrosion evaluation of cold-spray deposited copper on carbon steel (ADCS) by comparison to that of standard wrought copper. The specimens were exposed for three months to either neutral anaerobic or aerobic 3.0 mol/L NaCl solutions and the corrosion process followed by corrosion potential and periodic polarization resistance measurements. Subsequently, the specimens were analyzed by scanning electron microscopy (SEM) to detect any observable signs of corrosion damage and by energy dispersive X-ray (EDX) and X-ray photoelectron spectroscopies (XPS) and Raman spectroscopy to determine the composition and phase of any corrosion products formed. As expected, no corrosion damage was observed under anaerobic conditions and green cupric hydroxychlorides were deposited on the surface after exposure to aerobic solutions. More importantly, no significant differences were observed between the cold spray deposited and wrought copper specimens.

We have also performed a series of electrochemical tests using constant applied currents to accelerate dissolution of the copper. Currents of 10 or 30 $\mu A/cm^2$ (geometric surface area) were applied for a series of 24 hour periods. The electrochemically-treated specimens were then analyzed by SEM/ EDX, X-ray diffraction and Raman spectroscopy to determine the structure, morphology, and composition of the surface, including corrosion product deposits. In addition, profilometry was used to determine the roughness and topography of the treated interface. As expected the roughness of the cold spray deposited surface was much greater than that of the wrought specimen, but there was no evidence for the localized roughening (e.g., at particle boundaries) on the cold spray specimen.

To date no significant differences in corrosion behaviour between the wrought and cold spray copper have been observed. In particular, there is no evidence that the particle boundaries in the cold spray specimen are preferential corrosion sites.

References :

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