Effect of Cu Content on Corrosion Behavior and Chromate Conversion Coating Protection of 7xxx Series Al Alloys

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The addition of Cu in Al-Zn-Mg alloys increases the mechanical strength and resistance to stress corrosion cracking of 7xxx series aluminum alloys (AA7xxx). The peak aged T6 temper provides the maximum mechanical strength by precipitation hardening. However, the presence of noble Cu makes AA7xxx-T6 more susceptible to localized corrosion, such as pitting, crevice and intergranular corrosion (IGC). In order to protect AA7xxx-T6 from localized corrosion, protective chromate conversion coatings (CCCs) must be used. Cu has been reported to affect the CCC protection performance. The exact roles of Cu content in corrosion behavior and CCC protection of AA7xxx-T6 are the focus of this study. Polarization and Electrochemical Impedance Spectroscopy (EIS) approaches were used in combination with materials characterization techniques, such as Focused Ion Beam (FIB), SEM, TEM, High Resolution TEM (HRTEM), Scanning TEM (STEM), and X-ray Photoelectron Spectrometry (XPS).

Electrochemical tests on AA7xxx-T6 with various Cu content in deaerated chloride solution found that all alloys except for essentially Cu-free AA7004-T6 had two breakdown potentials, which increased logarithmically with increasing Cu content. Transient dissolution of the fine hardening precipitates and the surrounding solid solution in a thin surface layer was found in the Cu-containing alloys polarized at potentials between the two breakdown potentials. Stable dissolution associated with combined IGC and selective grain attack was found above the second breakdown potential. EIS tests revealed that the overall influence of Cu on the corrosion behavior was detrimental due to Cu enrichment in aerated chloride solution.

TEM and STEM analysis revealed that CCC was heterogeneous on the heterogeneous microstructure of AA7075-T6. The coatings formed on coarse intermetallic particles were much thinner than CCC formed on the matrix. It was found that the CCC formed on the matrix mainly consisted of a $Cr^{III}OOH$ backbone and chemisorbed $HCr^{VI}O_4^-$. A sol-gel model for CCC formation was supported by the observations in this study. Finally the Cu content can have different effects on CCC protection: Cu is beneficial to CCC protection for coatings formed on polished AA7xxx-T6, but Cu is detrimental if it is enriched on the surface prior to CCC formation.