THE EFFECTS OF MINOR ALLOYING ELEMENTS AND IMPURITIES ON THE WELD QUALITY OF NICKEL-CHROMIUM ALLOYS

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ABSTRACT

This thesis reports the results of at study aimed at determining the effects of low concentrations of impurities on automated gas tungsten arc welds made with nickel-chromium weld filler material. The study focused on two types of commercially available nickel-chromium alloys and their accompanying filler metals: Alloy 600 and Alloy 690, EN82H and EN52. Bead on plate, wire-fed welds were made on base plates intentionally doped with small quantities of several metals (Ni, Al, Mn, and Mg), one non-metal (S) and the corresponding metal oxides (NiO, Al_2O_3, MnO_2, MgO, and CaO). The doped and un-doped regions of each weld were measured for both width and depth and analyzed for a selection of elements using electron probe microanalysis (EPMA). In addition, unique surface features were characterized using scanning electron microscopy (SEM) and Auger electron spectroscopy (AES) and chemical analyses using inductively coupled plasma spectroscopy (ICP) and inert gas fusion-infrared absorbance of doped weld bead sections were performed. Results of this study reveal moderate to severe degradations in weld bead geometry in many of the doped beads, particularly welds doped with oxides. Adherent oxide films incapable of being removed by wire brushing were prevalent on the surfaces of all doped regions of the oxide-doped beads; oxide films were minimal on the metal and sulfur-doped welds. Depth to width (D/W) ratios of the oxide-doped bead sections each increased in excess of 15% in the Alloy 690-EN52 welds; changes in the metal and sulfur-doped bead sections were lower and within the observed variability of the startup and control bead sections in welds made with both alloy types. Oxide-doped beads exhibited a greater than two-fold increase in average oxygen content (79 ppm vs. 37 ppm) compared with their metal-doped counterparts. These findings are significant in that they demonstrate the effect a small amount (~ 40 ppm) of impurity, potentially introduced by accepted processing and preparation methods, can have on the macroscopic weld bead properties like dimensions and oxide growth. A chemical analysis using only EPMA WDS mapping or ICP spectroscopy is insufficient to conclusively establish a link between the elevated concentration of any one element and poor weld bead quality; the presence of a stearate-based drawing lubricant or residual alumina grinding media pre-welding could potentially impact the quality of a weld, but post-welding characterization will not necessarily confirm its existence.