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Effects of Boron on the Microstructure, Ductility-dip-cracking, and Tensile Properties for NiCrFe-7 Weld Metal

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The distribution of boron and the microstructure of grain boundary (GB) precipitates ($M_{23}(C, B)_6$ and M_2B) have been analyzed with their effects on the susceptibility of ductility-dip-cracking (DDC) and tensile properties for NiCrFe-7 weld metal, using optical microscopy (OM), secondary ion mass spectroscopy (SIMS), scanning electron microscopy (SEM), and transmission electron microscopy (TEM). The results show that boron segregates at GBs in NiCrFe-7 weld metal during the welding process. The segregation of boron at GBs promotes the formation of continuous $M_{23}(C, B)_6$ carbide chains and M_2B borides along GBs. The addition of boron aggravates GB embrittlement and causes more DDC in the weld metal, by its segregation at GBs presenting as an impurity, and promoting the formation of larger and continuous $M_{23}(C, B)_6$ carbides, and M_2B borides along GBs. DDC in the weld metal deteriorates the ductility and tensile strength of the weld metal simultaneously.

Key words: Boron; $M_{23}C_6$; M_2B; ductility-dip-cracking; tensile properties

1. Introduction

Nickel based Alloy 690 (Ni–30Cr–10Fe, mass fraction, wt%), is replacing Alloy 600 (Ni–16Cr–9Fe) as steam generator (SG) tubes in pressurized water nuclear reactors (PWR). Alloy 690 has superior resistance to intergranular stress corrosion cracking (IGSCC) and intergranular