ABSTRACT

The current study aims at investigating the implications of various microstructural parameters on both intergranular and pitting corrosion response in Alloy 600H. Towards this, the as-received (AR) specimens were subjected to both thermal and thermo-mechanical treatments to attain the desired microstructures. Thermo-mechanical processing comprising of a lower extent of deformation (7.5%) followed by an annealing treatment (at 1373K for 60 min) has yielded a grain boundary engineering (GBE) microstructure consisting of a higher fraction (~72%) of $\Sigma3^n$ ($n \leq 3$) boundaries and larger twin related domains size. This is because of the activation of strain-induced boundary migration (SIBM) that promoted extensive multiple twinning. However, application of the higher extent of deformation (~10% and 15%) has resulted in a lower $\Sigma3^n$ ($n \leq 3$) fraction and complex random high-angle grain boundaries (RHAGBs) network as a consequence of static recrystallization (SRX). Most importantly, the growth of the sparsely recrystallized grains nucleated in the 10% deformed specimen annealed at 1273K for 60 min did not result in a GBE microstructure even after prolonged annealing treatment (600 min), suggesting that GBE could not be achieved by activating SRX. The AR specimens were subjected to extended annealing treatments at high temperatures to realize a wide spectrum of coarser grain sizes whilst keeping other microstructural features constant. The effects of grain boundary character distribution (GBCD), residual strain, and grain size (including the grain size distribution) on sensitization phenomena and intergranular corrosion (IGC) response have been assessed. The GBE specimen exhibited enhanced resistance to IGC because of the larger fraction of $\Sigma3^n$ ($n \leq 3$) and disrupted RHAGBs network, thus suppressing the percolation of electrolytes. Residual strain in partially recrystallized microstructure facilitated the formation of Cr-rich precipitates *via* enhanced diffusion of Cr through dislocations resulting in greater sensitization. The fully recrystallized specimen showed enhanced sensitization due to the regeneration of RHAGBs network. In contrast, coarse-grained microstructures effectively delayed the diffusion of Cr from the interior of the grains to the RHAGBs. Interestingly, a 'Hall-Petch' type relation has been observed between the degree of sensitization (and weight loss) and grain size, and both of them varied inversely proportional to the $(\text{grain size})^{1/4}$. The sole effect of grain size variation on pitting corrosion and passive film behavior has been investigated through potentiodynamic polarization and electrochemical impedance spectroscopy (EIS) studies. Coarse-grained specimens exhibited a higher pitting resistance than the fine-grained counterparts. EIS analysis has revealed that the polarization resistance of the passive film increased with the grain size as the passive layer formed on the fine-grained specimens appears to be more defective due to the presence of higher RHAGBs surface area.

Keywords: Alloy 600H; Grain boundary character distribution; Grain boundary engineering; Grain boundary network; Grain size; Intergranular corrosion; Multiple Twinning; Passive film; Percolation; Pitting corrosion; Recrystallization; Sensitization; Strain-induced boundary migration; Thermo-mechanical processing; Twin related domain.