MmeCo08-001

Microstructural characterization and corrosion fatigue crack growth of 316L stainless steel

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Structural and mechanical components subjected to fluctuating service strain are susceptible to failure by fatigue. The 316L austenitic stainless steel, known as a marine-grade steel, has been increasingly used in corrosive environment due to its high corrosion resistance. However, the material is affected by chloride ions that lead to breakage of the chromium trioxide (Cr2O3) passive layer on the stainless steel surface. This fact may be a matter of concern in applications involving cyclic loading, leading to corrosion fatigue problems. In this scenario, the fatigue proprieties of the material in saline environment, where there is high chloride ions concentration, deserves a more detailed investigation. In the present work, the base metal microstructure, and the corrosion fatigue crack growth (FCG) rate of 316L austenitic stainless steel in 3.5 wt.% NaCl solution has been investigated. The results revealed that 316L exposed to NaCl solution demonstrated significantly decrease of corrosion fatigue properties compared to 316L in air, as reflected by the increasing of FCG rate. Microstructural observations by scanning electron microscopy (SEM) showed a clear deterioration of the microstructural conditions in the sample subjected to the aggressive environment. The increase in surface roughness and opacity demonstrates that the passive layer has broken. Additionally, a greater occurrence of microcracks was observed for lower values of stress intensity factor in the case of 316L in 3.5% NaCl, demonstrating a loss of microstructural stability through the emergence of microcracks not only at the delta ferrite/austenite interfaces, but also cracks in the delta ferrite as well, as observed by SEM micrographs. This fact may explain the reason why the FCG rate was higher for 3.5% NaCl sample than 316L in air. In both cases, there was the emergence of microcracks at the delta ferrite/austenite interfaces. However, in the case of the sample exposed to NaCl, the microcracks appeared at lower values of Delta-K and crack size, with the aggravation of cracks also occurring in delta ferrite. The better fatigue performance of 316L in air was demonstrated by the lower FCG rate at a given delta-K, for instance, 3.2 x 10-7m/cycle at 24MPa.m 0.5 in this condition compared to 4.9 x 10-7m/cycle in saline environment.