Electrochemical Noise Analysis of Pitting Corrosion of Thermally Aged Duplex Stainless Steel

Chan-Jin Park* and Hyuk-Sang Kwon*

*Dept. of Materials Science and Engineering, Korea Advanced Institute of Science and Technology, 373-1, Guseong-dong, Yuseong-gu, Daejon 305-701, Korea

Mechanical and corrosion properties of austenitic-ferritic (α+γ) duplex stainless steels (DSS) are significantly degraded due to precipitation of secondary phases such as sigma (σ), chi (χ) or alpha prime (α') phase when exposed to temperatures of 450 ^{o}C ~1100 ^{o}C due to an improper heat treatment or welding[1]. In view of corrosion, these secondary phases may act as preferential sites for pitting corrosion resulting from a depletion of chromium (Cr) or molybdenum (Mo) around them [1-3].

The motivation of this work is to investigate the effects of secondary phases on metastable pitting as a precursor of stable pitting corrosion and, additionally, on the further progress to stable pitting of 25Cr-7Ni-3Mo-0.25N DSS in chloride solution, through electrochemical noise analysis (ENA).

Electrochemical potential and current transients of the alloy were measured in 10 % ferric chloride solution with a zero resistance ammeter (ZRA), and then analyzed by power spectral density (PSD) and by corrosion admittance (A_c) spectrum.

With aging at 850 ^{o}C, the passive film of the alloy became significantly unstable as represented by an increase in power spectral density (PSD), and a transition from a metastable pitting state to a stable one was observed. In the corrosion admittance spectrum, the number of negative A_c corresponding to the state of localized corrosion increased with aging. This suggests that the precipitation of σ phase considerably degraded the passive film by depleting Cr and Mo adjacent to the σ phase that is formed at the α/σ or γ/σ phase boundaries, thereby leading to the initiation of the pitting corrosion. However, the Cr and Mo at the α/σ or γ/σ phase boundaries, which were once depleted due to the precipitation of the σ phase, were partly replenished by the diffusion of Cr and Mo from the surrounding matrix with aging time longer than 1 hr. The initiation of pitting corrosion appears to be associated with the precipitation density of the σ phase with an effective size needed to induce the sufficient depletion of Cr and Mo around it.

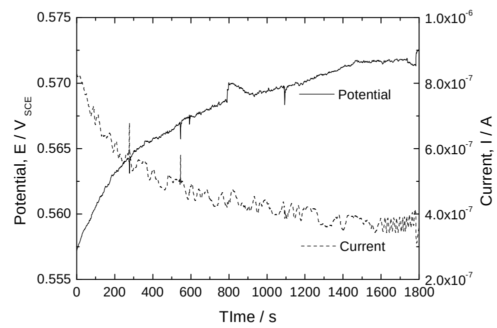

Fig. 1. Potential and current transients of the DSS, aged for 20 min at 850 ^{o}C, in 10 % ferric chloride solution at 60 ^{o}C.

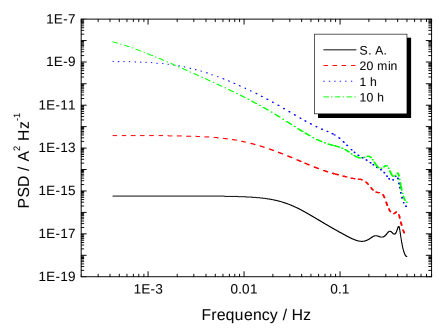

Fig. 2. Effects of aging at 850 ^{o}C on the current PSD of the alloy, obtained from the corresponding current transients.

References

1. J. O. Nilsson, Mater. Sci. Technol. 8 (1992), pp 685.

2. J. S. Kim, H. S. Kwon, Corrosion (2000), pp 32.

3. C. J. Park, M. S. Thesis, KAIST (1999).