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Corrosion Science 47 (2005) 2589–2598
CORROSION SCIENCE
www.elsevier.com/locate/corsci

Influence of the alloy element on corrosion morphology of the low alloy steels exposed to the atmospheric environments

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Received 29 August 2004; accepted 21 October 2004
Available online 6 June 2005

Abstract

Morphology of the corroded surface of low alloy steels beneath rust after long-term exposure test in the atmospheric environment was analyzed. The form of the corroded surface was measured with the laser displacement sensor scanning the surface. The resultant height map was divided by the mesh and the maximum corrosion depth was calculated in each cell. The maximum depth was arranged by the extreme value analysis. From this analysis two kinds of corrosion patterns were distinguished; i.e., uniform corrosion and local corrosion. Electrolytic iron shows the only uniform corrosion pattern. The addition of Cu, Ni and Cr changed the form of the corroded surface from the uniform corrosion to the combined pattern (uniform corrosion + local corrosion). The addition of Cr has a marked effect in changing the corrosion pattern.

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Keywords: Low alloy steels; Atmospheric corrosion; Corrosion form; Alloying effect; Gumbel distribution function

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doi:10.1016/j.corsci.2004.10.019

1. Introduction

Many investigators have studied the atmospheric corrosion of the low alloy steels. Particularly, investigations of the weathering steels by Misawa et al. [1–3] are well-known. We have reported also the corrosion loss and the analysis of the rusts on the surfaces of the low alloy steels exposed to atmospheric environments [4–6]. We have obtained only the averaged value from these analyses. A microscopic aspect was lacked in these analyses. Especially a few researchers are interested in the corrosion patterns of the corroded surface under the rust from a technological view point. Masuko et al. [7] executed the measurement of the atmospherically corroded surfaces of pure iron and Fe–1%Cu alloy by applying the Moire fringe patterns. They obtained the depth distribution profile of those materials and clarified the distribution of corrosion loss on an unevenly corroded surface. Yamamoto et al. [8] analyzed the characteristics of the atmospherically corroded surface by the two-dimensional fast Fourier transformation (FFT) method. They reported some cases that the periodicity appears on the auto-correlation coefficients obtained by the two-dimensional FFT method for the test piece with a large corrosion loss.

The main objective of the present work was to analyze the influence of the additional elements to the electrolytic iron from the morphology of the corroded surface using the depth profiling technique and the extreme-value statistics processing of the corrosion depth.

2. Experimental

2.1. Samples

The electrolytic iron and some Fe-binary alloys (0.4%Cu, 1%Cr, 3%Cr, 5%Cr, 9%Cr, 1%Ni, 3%Ni, 5%Ni, and 9%Ni) were used as the test pieces. Table 1 shows the chemical compositions of these alloys. Test pieces were plates with 150 × 100 × 5 mm. After degreasing, these test pieces were exposed at Tsukuba, Choshi, and Miyakojima

Table 1
Chemical composition of the samples

Material	C	Si	Mn	P	S	Cu	Cr	Ni	Al	Ti	V
Fe	0.001	<0.003	<0.001	0.0008	0.0011	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fe–Cu	0.001	<0.003	<0.01	0.0006	0.0007	0.43	<0.01	<0.01	<0.01	<0.01	<0.01
Fe–1Ni	0.001	<0.003	0.10	0.0003	0.0001	<0.01	<0.01	0.98	<0.01	0.Q1	<0.01
Fe–3Ni	0.001	<0.003	0.10	0.0005	0.0002	<0.01	<0.01	3.02	<0.01	<0.01	<0.01
Fe–5Ni	0.001	<0.003	0.11	0.0006	0.0003	<0.01	<0.01	5.01	<0.01	<0.01	<0.01
Fe–9Ni	0.001	<0.003	0.12	0.0005	0.0003	<0.01	<0.01	9.06	0.01	<0.01	<0.01
Fe–1Cr	0.005	<0.003	0.07	0.0010	0.0002	<0.01	1.01	<0.01	<0.01	<0.01	<0.01
Fe–3Cr	0.006	<0.003	0.05	0.0007	0.0001	<0.01	3.05	<0.01	<0.01	<0.01	<0.01
Fe–5Cr	0.003	<0.003	0.11	0.0003	0.001	<0.01	5.03	<0.01	<0.01	<0.01	<0.01
Fe–9Cr	0.003	<0.003	0.12	0.0002	0.0003	<0.01	9.03	<0.01	<0.01	<0.01	<0.01

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