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Integranular corrosion susceptibility analysis in austeno-ferritic (duplex) stainless steels

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Abstract

Austenitic-ferritic stainless steels combine the favorable properties of ferrite and austenite, showing both high mechanical properties and very good corrosion resistance. These steels are characterized by the precipitation of many secondary phases, carbides and nitrides for tempering temperatures between 200 and 1050°C. This phenomenon implies a high susceptibility to localized corrosion, however better than austenitic and ferritic grades. In this work, the susceptibility to intergranular corrosion in of two duplex stainless steel characterized by analogous ferrite/austenite volume fraction was investigated. A "standard" duplex stainless steel SAF 2205 and a "super" duplex stainless steel SAF 2507 were investigated by means of potentiostatic reactivations tests. In addition, chronoamperometric tests and light optical microscope observations of the specimens surfaces were performed in order to analyze the evolution of the corrosion morphologies.

Keywords: Duplex Stainless Steels; Intergranular corrosion; DL-EPR test.

1. Introduction

Because of their austenitic-ferritic microstructure, duplex stainless steels offer a good combination of mechanical properties and corrosion resistance compared to standard austenitic grades, Gunn (1997). They are widely used in chemical, petrochemical, fertilizer, nuclear and cellulose industries.

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These steels solidify liquid + ferritic field and it is during cooling of the solid that a partial ferrite transformation into austenite takes place. The amount of austenite and ferrite phases depends on chemical composition and cooling rate, Brandi (1997). The best combination of mechanical properties and corrosion resistance is obtained with a α/γ volume ratio near to 1. Duplex stainless steels are characterized by many microstructure modifications (Fig. 1).

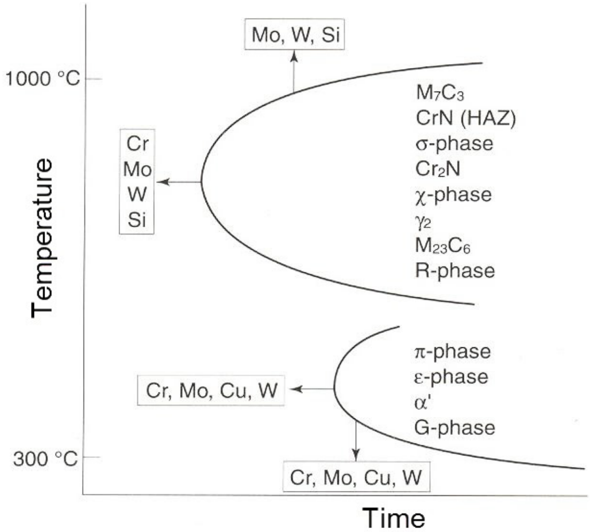

Fig. 1. Austenitic-ferritic stainless steels: T.T.T (Transformation–Time–Temperature) diagram.

Above 1050°C, austenite transforms into ferrite. This ferritisation process implies a modification both in volume fraction and in partition coefficients, with an increasing of interstitial elements content (e.g. hydrogen and nitrogen) in ferrite grains. Below 1050°C, duplex stainless steels show two different critical temperature ranges.

In the 600-1050°C range many carbides, nitrides, intermetallic and secondary phases could precipitate. Carbides M_7C_3 (between 950 and 1050°C), carbides $M_{23}C_6$ (between 600 and 950°C), nitrides (π, CrN, Cr_2N), intermetallic phases (σ, χ, R) and secondary austenite γ_2 precipitate in ferrite grains or in α/γ or α/α grain boundaries, Josefsson (1991). This precipitation implies a strong mechanical properties modification and an evident fatigue crack propagation resistance decreasing, Iacoviello (1997) and Iacoviello (1999).

In the temperature range between about 350 and 600 °C, the spinodal decomposition of ferrite grains and a fcc G phase precipitation at α/γ grain boundaries take place, Iacoviello (2005). G phase particles are characterized by a composition that varies according to the steel and to the ageing conditions, with the overall concentration of Ni+Si+Mo+Mn+Al that increase from 40 to 60% between 1000 and 30000 h at 350°C [10].

In this work, two duplex stainless steels (a 22Cr 5 Ni and a 25 Cr 7 Ni) with analogous ferrite and austenite volume fractions were considered and their susceptibility to the intergranular corrosion was investigated after sensitization at 800°C by means of DL-EPR tests, chronoamperometric tests and light optical microscope specimens surface observations.

2. Investigated steels and experimental procedures

The investigated duplex stainless steels chemical composition and tensile properties are shown in Tabs. 1 and 2.

Table 1. 22 Cr 5 Ni (%ferrite = %austenite = 50) chemical composition and tensile properties.

C	Si	Mn	P	S	Cr	Ni	Mo	N
0.019	0.39	1.51	0.022	0.002	22.45	5.50	3.12	0.169

YS [MPa]	UTS [MPa]	A%
565	827	35