Hydrogen trapping sites in AISI 316L and AISI 446 stainless steels

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Abstract

The most popular grades, thanks to their good mechanical and corrosion properties, are austenitic and ferritic stainless steel, which cover more than 95% of the global stainless steel production [1]. They are mainly used in the Oil and Gas, food, chemical and construction industries.

When a stainless steel is exposed to relatively high temperatures for long periods of time, the precipitation of various intermetallic compounds and phases can occur. This causes the sensitization of the steel, and consequently brings about reduction of its corrosion resistance. In a same way, intergranular carbides precipitation can generate fracture susceptibility along boundaries. In general, hydrogen can have a deleterious effect on metals, since only a small amount is enough to cause serious degradation of corrosive and mechanical properties. Second phases play very important role in the hydrogen trapping behavior [2,3,4,5] and have a significant effect on the possible hydrogen embrittlement mechanism.

In this work several thermal treatments were carried out, considering different cooling conditions on two stainless steels grades, AISI 316L and AISI 446. Specifically, the objective of this work is to show the effects of different kinds of precipitates (such as, carbides and intermetallic phases) acting as hydrogen traps which can naturally affect the corrosion behavior of steels [4].

Hydrogen charging were performed by the cathodic permeation method with graphite anode and constant current density of 35 mA/cm^2 for 3.5h. A 1N H_2SO_4 electrolyte solution was used, with the addition of 0.25 g/L of $NaAsO_2$, before and after heat treatments.

The microstructural characterization carried out in both steels allowed to detect a wide variety of carbides, with variable chromium contents and different morphologies. The ferrite-carbide interfaces could be identified as the main hydrogen trap sites in the AISI 446, and the grain boundaries in the AISI 316L.

Recent Publications

[1] Charles J. Past. Present and future of the duplex stainless steels. ARCELOR MITTAL STAINLESS/UGINE&ALZ/Dir. I-R&D 5-7, rue Luigi Cherubini, 93210 LA PLAINE SAINTDENIS Cdx, France.

[2] Silverstein R., Glam B., Eliezer D., Moreno D., Eliezer S. (2018) Journal of Alloys and Compounds 731:1238-1246.

[3] Yu C., Shiue R.-K., Chen C., Tsay L.-W. (2017) Metals, 7, 58; doi:10.3390/met7020058 2-14.

[4] Garcia D.S.C., Carvalho R. N., Lins V. F. C., Rezende D. M., Dos Santos D. S. (2015) International Journal of Hydrogen Energy 40: 17102-17109.

[5] Argandoña G., Palacio J. F., Berlanga C. , Biezma M. V., Rivero P. J., Peña J., Rodríguez R.(2017) Metals, 7, 219; doi:10.3390/met7060219- 1-12.



Biography

Prof. Dr. Graciela Mansilla, born 1963, received her MSc and PhD in Physics at the National University of Rosario, Argentina. She is currently Associate Professor and Researcher at the National Technology University of San Nicolas (UTN-FRSN), Argentina. Her working area is associated with Physical Metallurgy of ferrous and non ferrous alloys (stress relaxation, tensile and fatigue behaviour, wear and hydrogen embrittlement). She has numerous publications in Congresses and Journals of scientific interest.

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Biography

Prof. Eng. Mariano Inés, born 1985, received his Metallurgical Engineer degree at the National Technology University of San Nicolas (UTN-FRSN), Argentina. He is currently professor and researcher at the UTN-FRSN, Argentina. His work area is related with hydrogen embrittlement of steels and its alloys. Currently he is working on his PhD in engineering at the Physical Metallurgy Laboratory of the UTN-FRSN.

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