11th International Conference
on Advanced Materials

Rio de Janeiro Brazil
September 20 - 25

ICAM2009

Sensibility of mechanical and electrochemical tests in detecting alpha prime phase in duplex stainless steels aged at 475 ºC

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Abstract – Alpha prime formation leads to material embrittlement and decreases corrosion and mechanical resistance. In the present study, some tests as microhardness, impact test, electrochemical impedance spectroscopy and cyclic polarization were performed with the duplex stainless steel (DSS) UR 52N+aged at 475 ºC from 0.5 h to 1,032 h in order to evaluate the sensibility of these tests in detecting alpha prime presence. After 0.5 h of aging at 475 ºC it was observed that impact test indirectly revealed the presence of this deleterious phase in the DSS studied, and this test was the most sensible for detecting alpha prime among the other ones used.

Duplex Stainless Steels (DSS) have been extensively used in nuclear, chemical and petroleum industries due to their good weldability, mechanical and corrosion resistance, especially in aggressive environments. Despite their superior properties, they are susceptible to precipitation of deleterious phases when exposed to specific temperatures that result in deterioration of mechanical and corrosion resistance properties, which could be related to the precipitation of a chromium enriched phase, called alpha prime. This precipitation is most favored at 475 ºC, leading to embrittlement [1-3].

The purpose of this work is to evaluate the capability of some mechanical and electrochemical tests to detect alpha prime in the UR 52N+DSS aged at 475 ºC from 0.5 h to 1,032 h. Some tests as microhardness, Charpy impact test, electrochemical impedance spectroscopy (EIS) and cyclic polarization were performed with solution annealed (1200 ºC for 1 h) and also with aged samples. Microstructural characterization was carried out with some samples etched with modified Behara etchant.

The results obtained by impact test showed that it is the most susceptible among the tested ones to alpha prime presence in the DSS aged at 475 ºC. The effect of alpha prime on hardness was only indicated by microhardness tests for samples aged longer than 24 h; on pitting potential, the effect of this phase was only found by cyclic polarization tests for samples aged during 96h and a minimum aging time corresponding to 762 h was necessary to indicate the alpha prime effect by EIS tests. The impact test results showed huge toughness loss with aging time. Comparison of absorbed energy data of aged specimens in relation to solution annealed ones showed that for aging times up to 12 h, there is a huge decrease of absorbed energy (about 90%) and it continuously decreased for longer aging periods. The decrease of absorbed energy might be explained by ferrite phase hardening when the alpha prime chromium enriched phase forms. Besides, alpha prime phase favors the pinning of dislocations, decreasing the ductility of the material.

The easy sample preparation and test accomplishment associated to the Charpy impact test, besides its high susceptibility in detecting alpha prime effect that leads to embrittlement at 475 ºC, compared to the other tests performed in this study, make this test the most appropriate to indirectly detect alpha prime presence in the aged DSS tested.

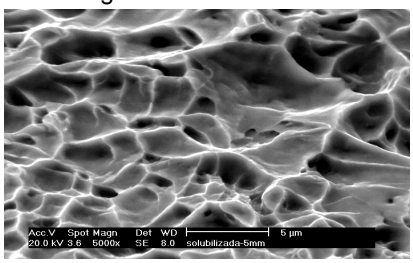

Figure 1: SEM image of a solution annealed DSS. The fracture is typically ductile and dimples are observed along the specimen.

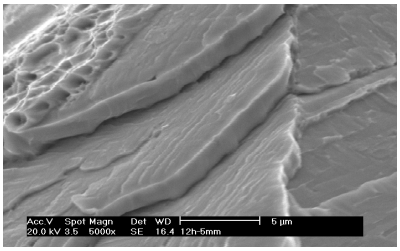

Figure 2: SEM image of a 12 h aged at 475 ºC DSS. The fracture failure is brittle. Cleavage plans are clearly observed along the specimen and also a small area with dimples.

References

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