cbecimat26
26° Congresso Brasileiro de Engenharia e Ciência dos Materiais
Costão do Santinho - Florianópolis/SC

INFLUENCE OF REVERTED AUSTENITE ON THE CORROSION RESISTANCE OF 17-4PH PRECIPITATION-HARDENING STAINLESS STEEL

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What do we know?

FUNDAMENTALS

17-4PH (AISI 630) is a stainless steel hardened by precipitation of nano rich particles of Copper (ε-Cu) [1].

AGING CONSEQUENCES

Reverted austenite (γ_{rev}) forms during aging through the transformation of martensite.

γ_{rev} CONSEQUENCES

Modifies local electrochemical behavior, hardness and toughness of the martensitic matrix [2].

Objective

To investigate the influence of aging-induced microstructural changes of the electrochemical behaviour and localized corrosion resistance of 17-4PH stainless steel.

Scientific Challenge

"Difficulty in isolating the electrochemical contribution of reverted austenite (γ_{rev}) from that of Cu-rich precipitates (ε-Cu), which exhibit a more cathodic behavior.

Experimental Approach

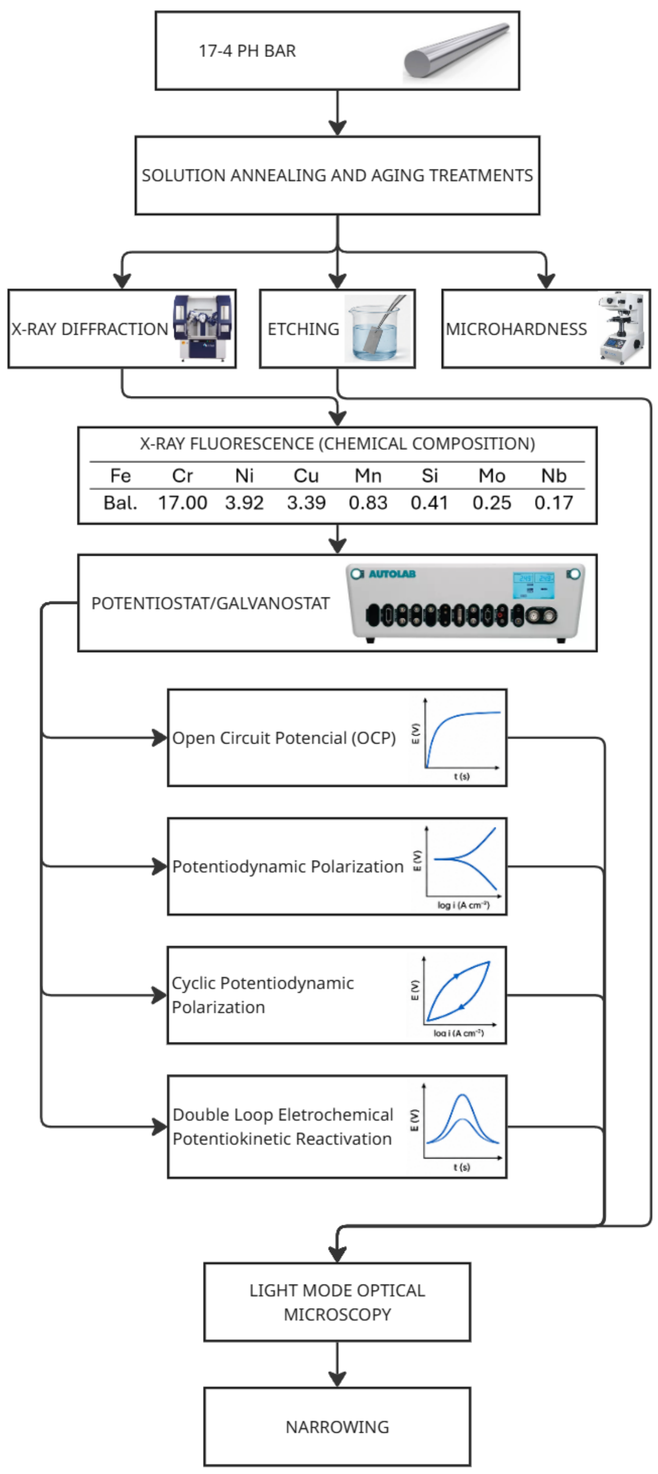


Figure 1 – Experimental Methodology Flowchart

Results

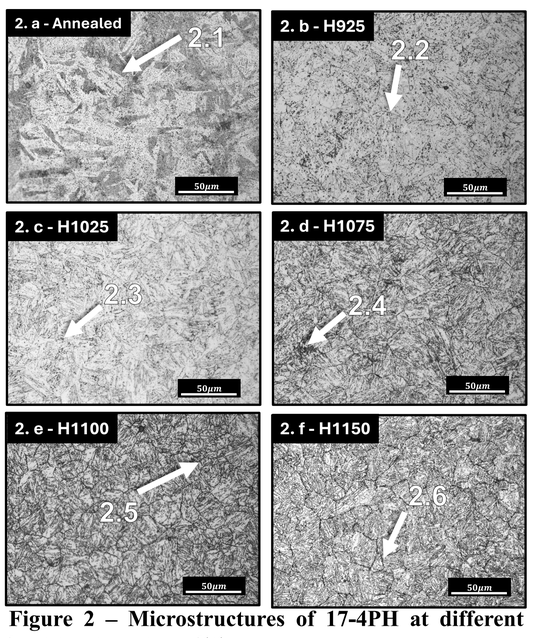


Figure 2 – Microstructures of 17-4PH at different heat treatment conditions.
The arrow indicates regions associated with the following microstructural changes:
(a) 2.1 – Solution-Annealed: Predominantly martensitic matrix;
(b) 2.2 – H925: Initial copper precipitation and onset of austenite reversion;
(c) 2.3 – H1025: Evolution and coarsening of copper-rich precipitates;
(d) 2.4 – H1075: Progressive austenite reversion and precipitate coarsening;
(e) 2.5 – H1100: Further microstructural evolution and austenite formation;
(f) 2.6 – H1150: Maximum reverted austenite fraction (20.9%), with advanced precipitate evolution.

Microhardness

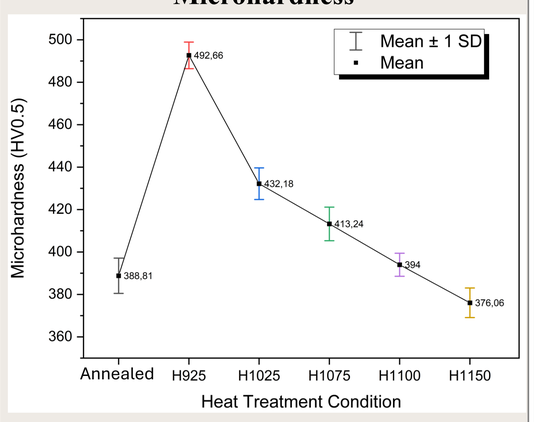


Figure 3 – Microhardness tests with 0.5 kgf.

X-Ray Diffraction

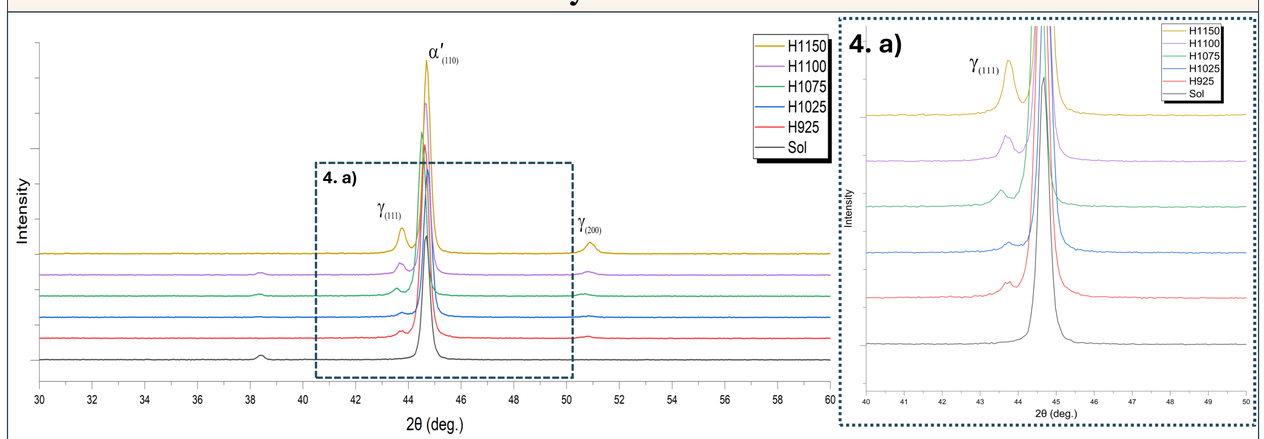


Figure 4 – X-ray diffraction patterns of 17-4PH steel under different heat-treatment conditions. Black: solution-annealed; red: H925; blue: H1025; green: H1075; purple: H1100; and yellow: H1150.

Rietveld refinement indicated a reverted austenite fraction (111) of 0% in the solution-annealed condition and 20.9% after H1150 aging

Electrochemical tests

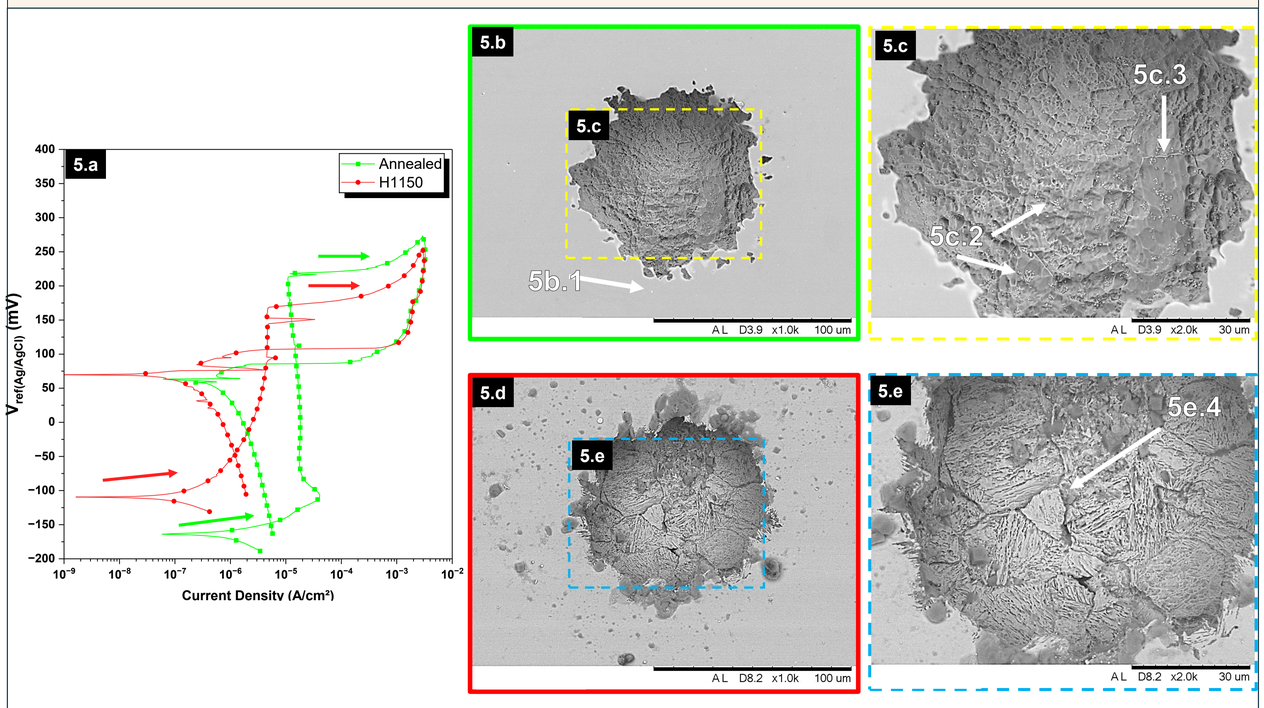


Figure 5 – Corrosion behavior and surface morphology of 17-4PH pits in the solution-annealed and H1150 conditions: (a) cyclic potentiodynamic polarization curves; (b,c) SEM micrographs of the solution-annealed sample after polarization; (d,e) SEM micrographs of the H1150 sample after polarization. Arrows indicate:
(b) 5.1: Niobium Carbide formed at annealing;
(c) 5.2: Possible sensitization;
(c) 5.3: Niobium Carbides precipitates at grain boundaries;
(e) 5.4: Pronounced intergranular attack, potentially associated with Cu-rich precipitates.

Conclusions

- **XRD revealed γ(111) and γ(200) reflections that grow with aging temperature and are absent in the solution-annealed steel; Rietveld refinement gave 0% reverted austenite (Sol) and 20.9% (H1150).**
- **In the cyclic polarization curves (mV vs. Ag/AgCl), the solution-annealed steel showed a lower Ecorr (≈ −165 vs. −110 mV) and a higher Epit (≈ 220 vs. 170 mV) than H1150, resulting in a larger ΔE and a slightly higher resistance to pitting.**
- **The repassivation potential was similar for both conditions, indicating comparable repassivation behavior.**
- **The pits had similar diameters (≈ 91.7 vs. 87.3 μm) but were markedly different: NbC particles dispersed on the pit floor of the solution-annealed steel, and intergranular attack at the pit bottom of H1150, associated with Cu-rich precipitates.**

References

[1] C. Zhou, Y. Lv, L. Zhang. *The Effect of Aging Treatment on the Corrosion Behavior of 17-4PH Stainless Steel.* Materials 18 (2025) 1823. doi:10.3390/ma18081823

[2] S.S.M. Tavares, F.J. da Silva, C. Scandian, G.F. da Silva, H.F.G. de Abreu. *Microstructure and intergranular corrosion resistance of UNS S17400 (17-4PH) stainless steel.* Corrosion Science 52 (2010) 3835–3839. doi:10.1016/j.corsci.2010.07.016

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Acknowledgments

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