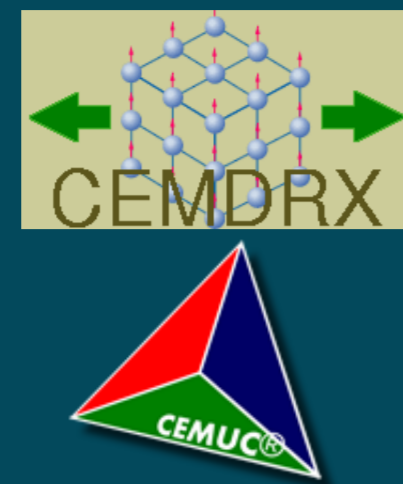


STUDY OF THE INFLUENCE OF POST WELD HEAT TREATMENT (PWHT) ON THE SALT SPRAY CORROSION BEHAVIOUR OF 316L STEEL CLAD



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ABSTRACT

Austenitic stainless steels are the most used materials for pressure vessel applications due to their excellent corrosion resistance under diverse service conditions. In the present work multilayer steel clads were produced by submerged arc welding (SAW) on plates of carbon steel using electrodes of AISI 309L (first layer) and 316L (second and third layers). The thickness of the 3-layer clad is 9.4 ± 0.5 mm. Post-weld heat treatment (PWHT) of the clads was carried out using two different conditions. Some of the clads were treated at a temperature of 540 °C for 10 h (HT540) and others were treated at 620 °C for 1 h (HT620). Accelerated corrosion tests were conducted using a cyclic corrosion test chamber. Samples of size 70x65x25 mm were cut from NHT, HT540 and HT620; the top surfaces were ground and polished to a mirror finish using SiC abrasives and then diamond particles; the side and bottom surfaces were coated by varnish for protection. Two salt spray tests were conducted.

Cladding process (Submerged Arc Welding - SAW)

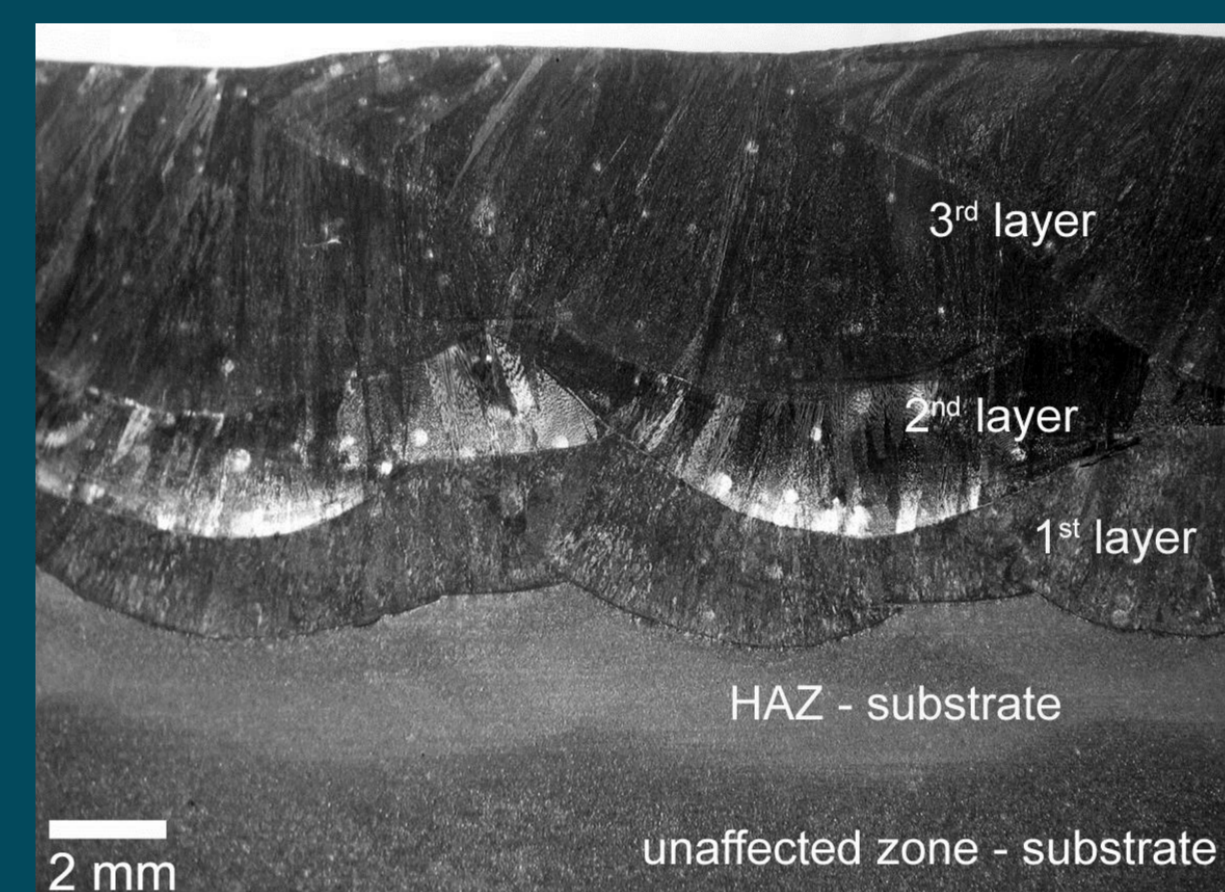


- **Base material:** ferritic steel P355 NH
- **1st layer:** austenitic stainless steel 309
- **2nd and 3rd layer:** austenitic stainless steel 316 L
- **Produced by** ARSOPI S.A., Portugal

Heat treatment parameters after SAW

- **HT540:** temperature 540 °C / 10 h
- **HT620:** temperature 620 °C / 1 h
- **NHT:** non-heat-treated sample

Typical cross section microstructure of all samples



Process Equipment



ARSOPI S.A., Portugal

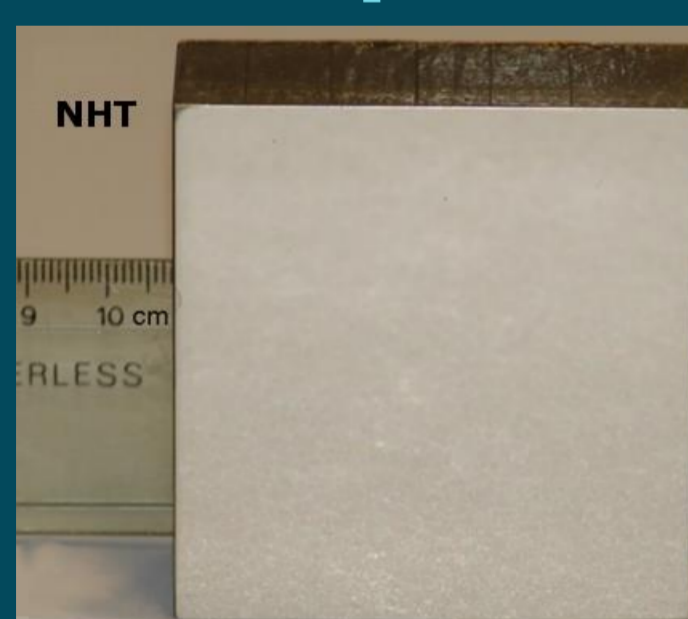
Accelerated corrosion test

TEST 1 The sample surfaces were exposed to a salt spray solution of 1.0 ± 0.1 % NaCl, pH 6.5 at a rate of 1-2 ml per 80 cm² per hour at a temperature of 35 ± 2 °C for 240 h.

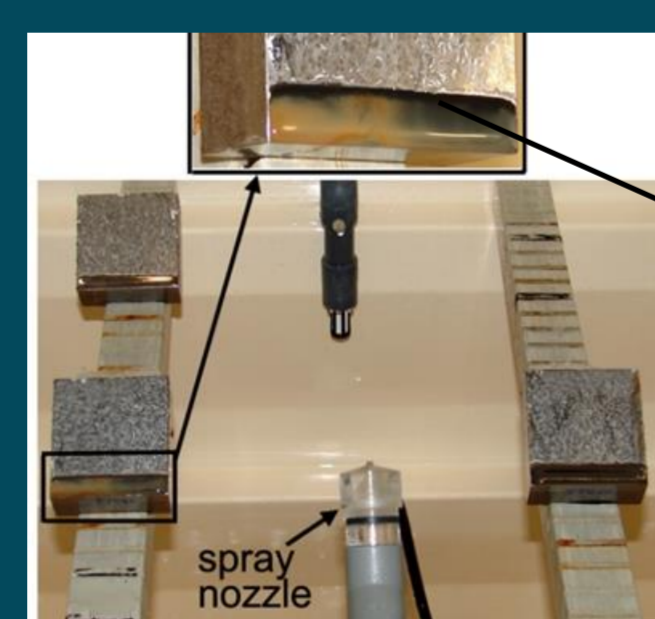
TEST 2 was carried out using a solution of 5.0 ± 0.5 % NaCl, pH 6.5 and consisted of two phases:

- **first phase:** salt spray exposure for 240 h with conditions similar to Test 1;
- **second phase:** cyclic corrosion test (CCT), each cycle consisting of the following steps:
 - (i) salt spray exposure for 2 h
 - (ii) drying for 4 h at 60 °C and 10 % relative humidity (RH)
 - (iii) exposure for 2 h at 90 % RH at 50 °C. The cycle was repeated 9 times.

Surface before salt spray test exposure



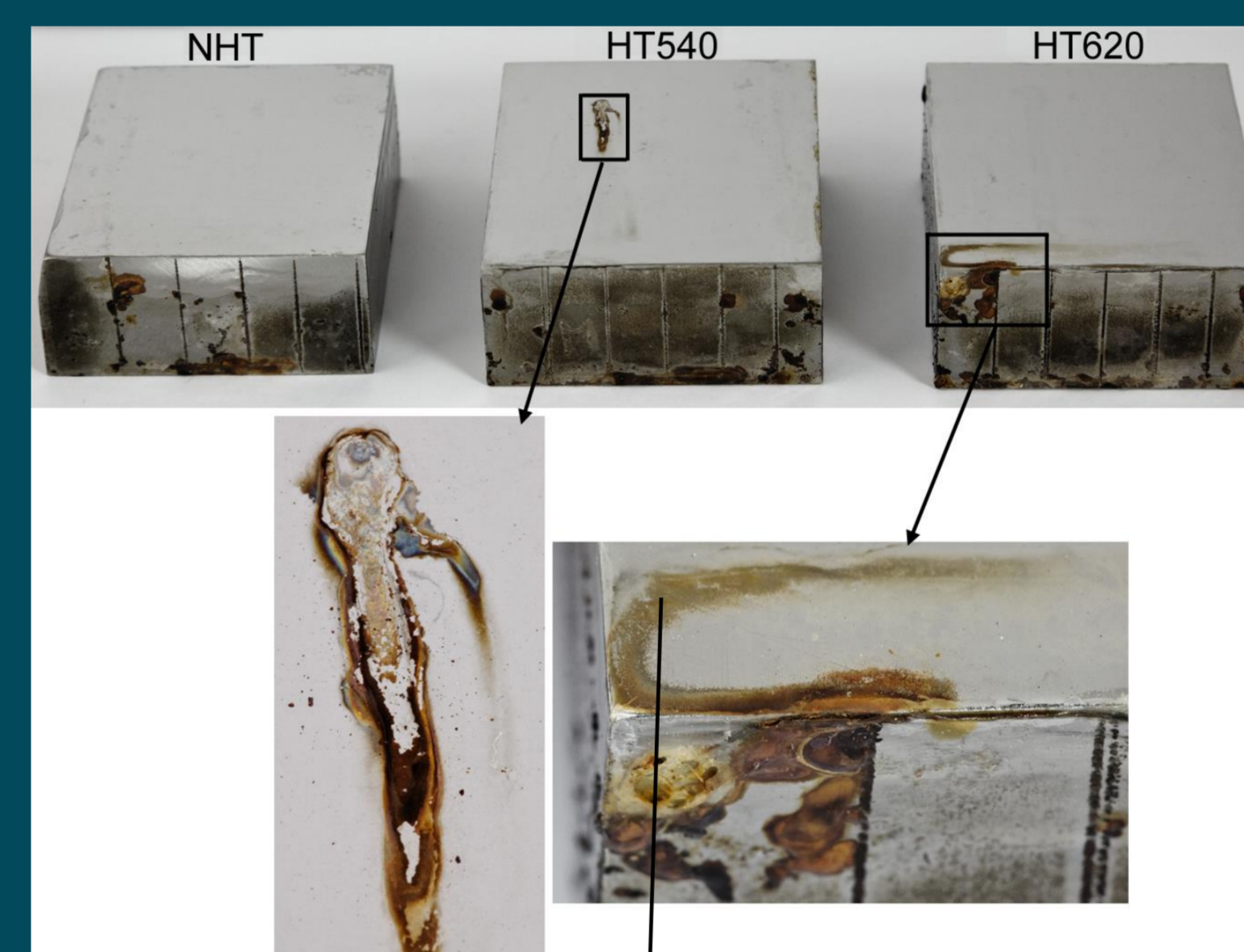
Arrangement of samples inside the test chamber



Salt solution stagnant at the bottom of the sample

Sample surfaces after exposure

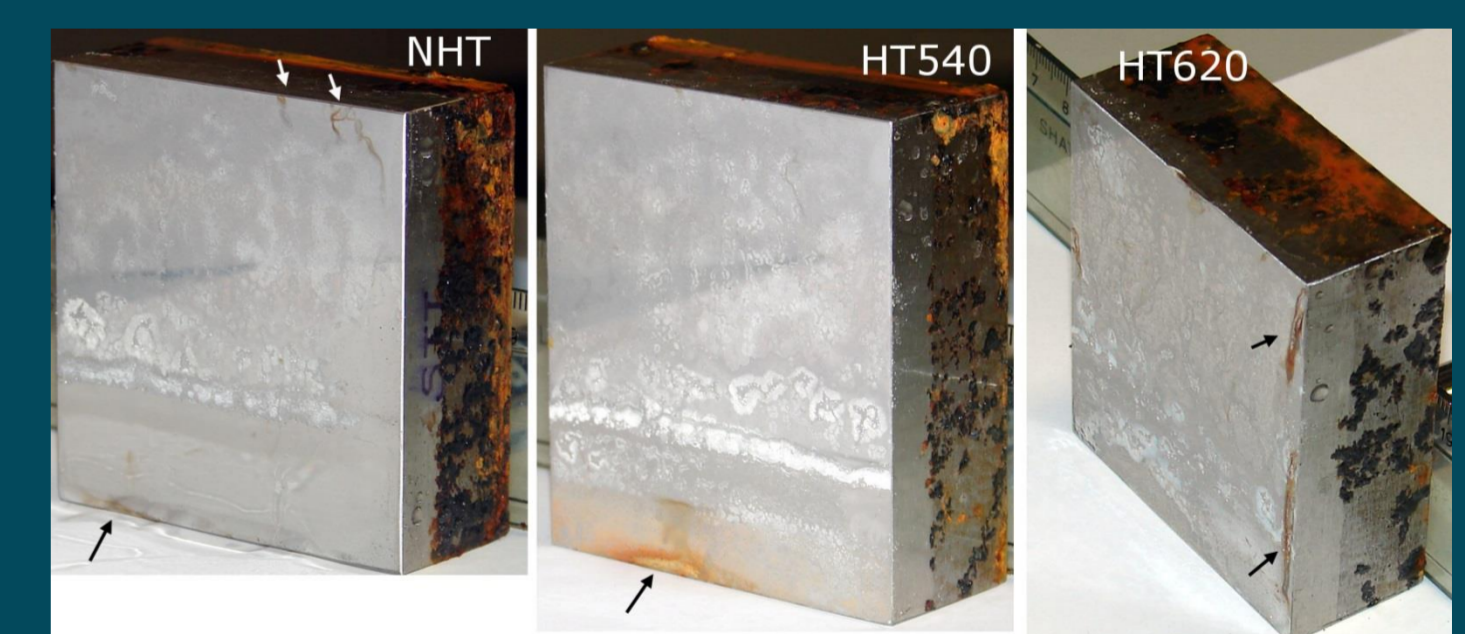
Test 1, after 240 hour



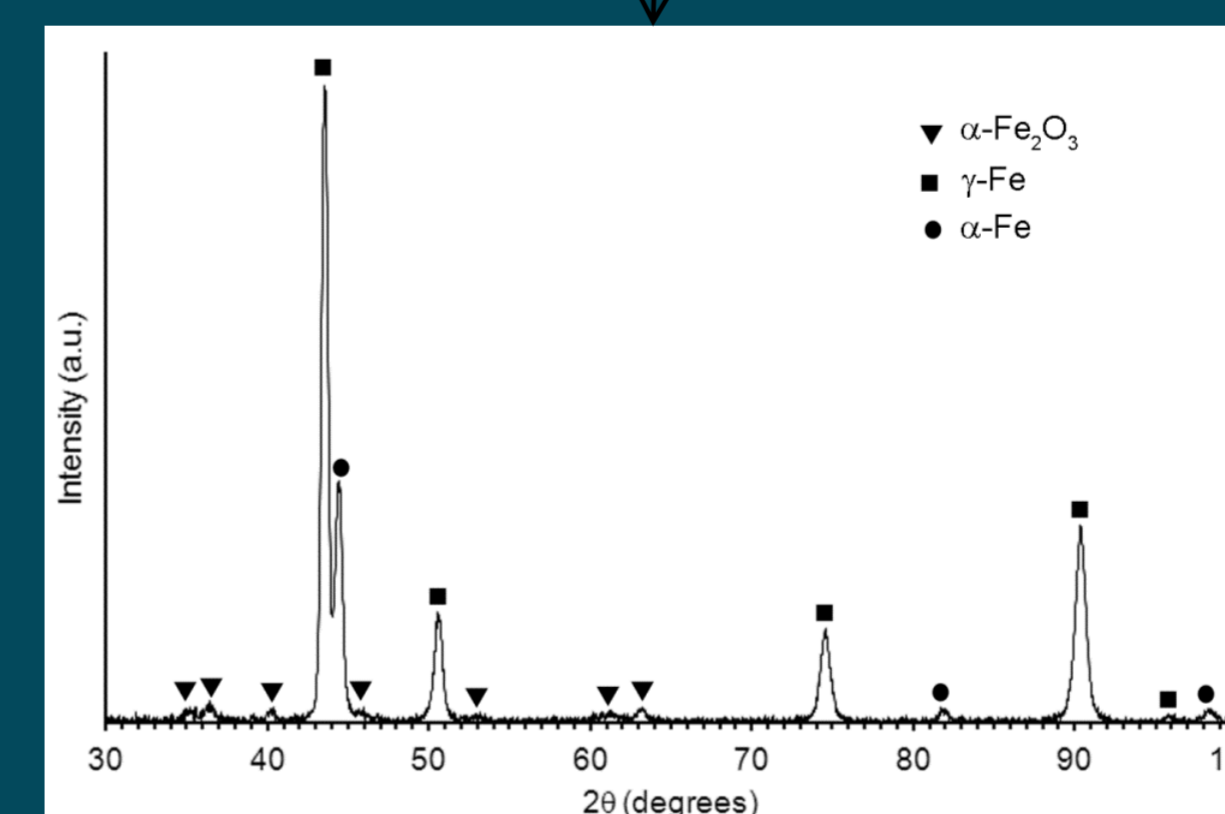
Test 2, after 24 h



Test 2, after 240 h



After the Cyclic Corrosion Test



(arrows indicate visible red corrosion areas)

Conclusions

In Test 1, the surface of NHT presented no significant change, while HT540 and HT620 showed some localized red-brown rust. X-ray diffraction analysis showed that the rust consists mainly of α -Fe and α -Fe₂O₃; the diffractogram also has peaks of γ -Fe resulting from material adjacent to the rust.

In Test 2 after the first phase the sample surfaces presented a very small amount of localized red-brown rust. These results confirm that non-heat-treated and heat-treated materials possess good corrosion resistance under the tested conditions. However, in test 2 after CCT, the surface of HT620 presented significant localized corrosion, NHT showed some localized rust and HT540 insignificant change.

The results obtained confirm that PWHT at 620 °C deteriorates the corrosion behaviour of the material under CCT conditions. The partial transformation of residual δ -ferrite to σ (a Fe-Cr intermetallic) during the heat treatment produces Cr and Mo deficiency in regions adjacent to the σ phase. As a result, the passive film becomes weaker in those regions and leads to localized corrosion.

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