

STUDIES ON THE DEGREE OF SENSITIZATION OF WELDED 2507 SUPER DUPLEX STAINLESS STEEL USING A MODIFIED DL-EPR TEST PROCEDURE

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SUMMARY: Duplex stainless steels are chosen for many engineering applications in harsh and aggressive environments. However, a major drawback associated with the welding of these materials is increased susceptibility to sensitization. Many of the sensitization tests developed for stainless steels are destructive and only provide qualitative information. One non destructive method, namely a modified double loop electrochemical potentiokinetic reactivation (DL-EPR) test has been developed and applied successfully for quantitatively assessing the degree of sensitization in 2205 duplex stainless steels. However, this test is not suitable for the 2507 super duplex stainless steels. The focus of this study was to develop and optimize a procedure based around the DL-EPR test for assessing sensitization in super duplex stainless steels (AISI 2507). The study focused on optimization of the test parameters in order to induce sensitization in the samples. Metallographic samples were prepared from AISI 2507 SDSS 10 mm welded plate. Potentiodynamic scanning was performed from active to passive regions with a scan rate of 1.67mV/s, in selected electrolyte (acid and depassivator) media at varying concentrations and temperatures. The various weld regions, prior to and after corrosion testing, were characterized using optical microscopy, scanning electron microscopy and EDX analysis in order to determine morphological and compositional features and mechanisms associated with induced sensitization. The results from these findings are presented in this paper and the implications of the results discussed in terms of precipitation effects, chromium depletion, and sensitization of the different weld regions.

Keywords: Duplex Stainless Steel, SDSS, DLEPR, Sensitisation and Intergranular Corrosion.

1. INTRODUCTION

Duplex (ferritic/austenitic) stainless steels are widely used in many industries such as oil and gas, pulp, and power plant, due to their high performance and superior characteristics which arise from coexistence of ferrite and austenite phases in equal amounts [1]. Duplex stainless steels have higher strength than austenitic stainless steels, higher toughness than ferritic stainless steels, good weldability, and high resistance to different forms of corrosion in a variety of aggressive environments [2].

However, a limitation associated with this group of steels is that during fusion welding, the duplex stainless steel base metal is subject to a series of thermal cycles, resulting in complex microstructural transformations and associated dissolution of ferrite, thus altering the ferrite / austenite (δ/γ) ratio. This can lead to the formation of secondary austenite and other undesirable chromium enriched intermetallic phases such as $M_{23}C_6$, sigma, chromium nitride and chi phases [3]. These secondary phases may sensitise the duplex stainless steel by creating adjacent chromium depletion regions and affecting their resistance to intergranular corrosion [4-6].

Standard corrosion tests [7, 8] are typically used to evaluate the intergranular corrosion (IGC) susceptibility. These tests are difficult to perform in situ and the interpretation of the results, especially in the case of extensive small secondary phases, is very difficult, requiring a significant quantity of material for testing, which can affect the integrity of the pieces during inspection. Because of the need for a non-destructive examination, a double loop electrochemical potentiokinetic reactivation (DLEPR) test was developed [4,9].

The DLEPR test, an electrochemical test based upon cyclic polarisation, is a modified version of the ASTM standard G108 test initially developed to measure the degree of sensitisation of austenitic stainless steels, grades 304 and 304L, and susceptibility to intergranular corrosion [10]. It has been shown for stainless steels that although this technique is highly sensitive to electrolyte composition and operating conditions, the reliability of the test results is still maintained. However, it was not considered suitable for duplex stainless steels as selective attack of the ferrite occurs during the polarisation scan [11] and therefore a modified double loop test was developed by Schultz et al. [12]. Generally for duplex stainless steels, the electrolyte employed is aqueous sulphuric acid (H₂SO₄) with the addition of NaCl or KSCN as a depassivator. [4]. Although the modified double loop test was optimised to suit most grades of duplex stainless steel, it was not found suitable for super duplex stainless steel as they remain passive, i.e. no signs of sensitisation under the applied test parameters were observed [13].

To detect the effect of very fine precipitates using the DL-EPR test, appropriate electrolyte composition, temperature, potential limits and scan rates need to be determined for each specific alloy. The objective of the present study was to determine the optimum conditions as mentioned to measure the degree of sensitisation and susceptibility to IGC for AISI 2507 SDSS using a DL-EPR test

2. EXPERIMENTAL PROCEDURE

2.1 Material Specifications

SAF 2507 super duplex stainless steel metal plate with 10 mm wall thickness was used in this study. Multipass welding was carried out using standard gas tungsten arc welding (GTAW), and 2507 filler wire (AWS A5.9 "ER25.10.4.L). The chemical composition of the base metal and the employed filler materials as quoted by the supplier (Sandvik) are shown in Tables 1 and 2.

Table (1) Chemical composition for AISI 2507 duplex stainless steel plate

P (max)	S(max)	C(max)	N(max)	Si	Cr	Mn	Fe	Ni	Mo	Total
0.035	0.015	0.03	0.3	0.8	25	1.2	61.67	7	4	100

Table (2) Chemical composition for the used 2507 filler wire

C	Cr	Ni	Mo	N	Mn	Si	Fe
0.02	25	9.5	4	0.25	0.4	0.35	Rest

2.2 Microstructural Evaluation

ASTM A923 method A was employed to confirm the existence of intermetallic phases in the sensitised material and their absence in the unsensitised samples [14, 15]. Test specimens were initially mounted, ground and polished to 3µm using standard metallographic preparation techniques. Samples were then electrochemically etched in a 40% NaOH solution at 3V for 15-60 seconds. The resultant microstructure was evaluated using optical light microscopy (OLM), scanning electron microscopy (SEM) FEI Nova Nano-SEM (2007) with EDAX Si (Li) X-ray detector.

2.3 Sensitisation Studies using the DLEPR Test

The principle of the DLEPR test is based around the formation of an activation peak on the forward scan when going from the active to the passive region and likewise the reverse polarization from the passive to the active region should give rise to a reactivation peak, the magnitude of which should be sensitive to the degree of alloy element depletion. The susceptibility to corrosion is characterized in terms of either the ratio of the magnitude of the reactivation-current peak (I_r) to the activation current peak (I_a) or the ratio of the reactivation charge to the activation charge (Figure 1).

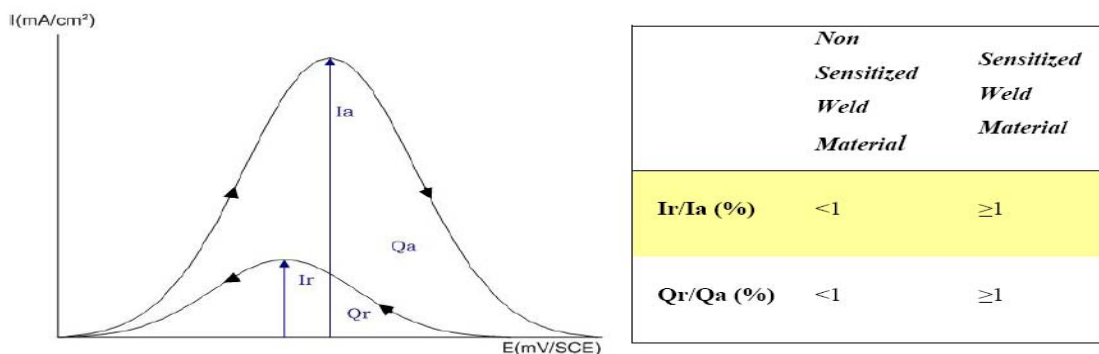


Figure 1 Principle of DL-ERP for degree of sensitisation (DOS) studies [1]

All DLEPR tests were conducted using an Autolab Potentiostat, using a three electrode setup where the sample under study was the working electrode, a 3M Ag/AgCl reference electrode and a platinum counter electrode. The electrolyte solution used in this study was a variation on the H_2SO_4 + thioacetamide (TA) mixture used for assessing 2205 duplex steels, where TA is used as a depassivator [1]. Specimens were initially immersed in the solution at a potential of -500 mV for 1 minute to improve reproducibility and then at the open-circuit potential (E_{ocp}) for 5 minutes to ensure a steady open circuit potential E_{ocp} [3]. A potential sweep was then performed from -500 mV to +200 mV and then back to -500 mV at a scan rate of 1.67 mV/min. This range was chosen to ensure the sample was brought into the passive domain.

In order to optimise the test conditions for this particular grade (AISI 2507) super duplex steel DLEPR studies were carried out under the following conditions; H_2SO_4 concentration (0.5, 1, and 2 M); TA concentration (0.001, 0.005, and 0.01 M); temperature (60 to 70°C) and voltage scan range (from -500 to +200 mV, and from -500 to +100 mV). It should be noted that each test was repeated twice to ensure reproducibility.

The test conditions were optimised by means of a response test, which was characterised by weak values of the current density ratio ($I_r/I_a < 1\%$) for non-sensitised materials, and relatively high ratio values ($I_r/I_a \geq 1\%$) for highly-sensitised materials as reported previously [4, 16].

3. RESULTS AND DISCUSSIONS

3.1 Microstructure Evaluation

Illustrated in Figure 2 is a photograph of a welded 2507 SDSS plate and in Figure 3 the macro structure appearance of the weld joint.

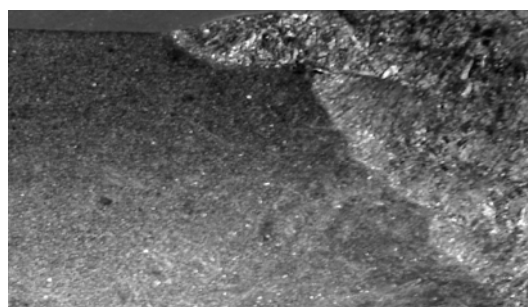
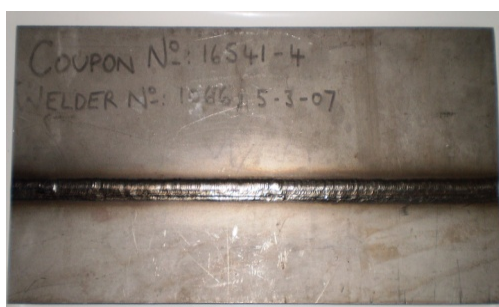


Figure 2 as received AISI 2507 welded plate

Figure 3 macro structure appearance of half weld joint

Figure 4 shows a SEM of the base metal where the microstructure can be clearly seen which shows the coexistence of equal amounts of both ferrite and austenite phases. Here, the dark region is associated with the presence of ferrite and the bright regions with austenite. Identification of these two phases based on EDXS analysis (Figure 5) and quantified in Table 3. The ferrite phase contains a higher concentration of ferrite promoting elements such as Cr, and Mo. Likewise, the austenite phase contains a higher concentration of austenite promoting elements such as Mn, Ni, and nitrogen. The volume fraction of ferrite and austenite in the base metal was determined using ASTM E-562 [17]. The obtained results (Table 4) confirmed the coexistence of an almost equal amount of ferrite and austenite phases in the base metal.

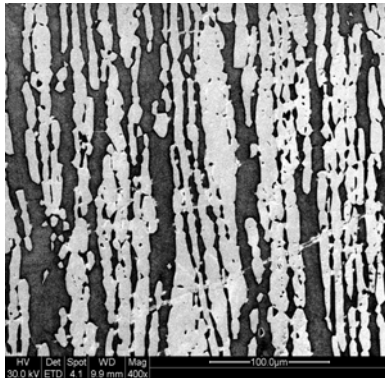


Figure 4 Microstructure of etched SAF 2507 base metal

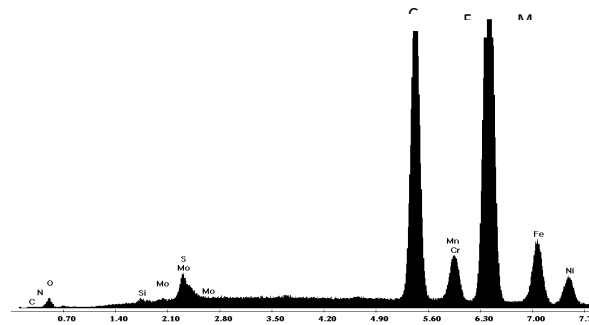


Figure 5 Qualitative EDXS analysis for the SAF 2507 Base metal

Table 3 Chemical composition of austenite and ferrite phases

	P	S	C	N	Si	Cr	Mn	Fe	Ni	Mo	Total
Ferrite	0	0	0	0	0.71	25.63	0.85	61.3	5.96	5.55	100
Austenite	0	0	0	0.23	0.64	23.41	0.92	62.35	8.28	4.17	100

Table 4 Volume fraction of ferrite and austenite in the base metal

	Austenite	Ferrite	Total
Total Area (mm²)	0.86	0.78	1.64
%	51.83	48.17	100

Figure 6 shows SEM images of the weld joint. It should be noted that there is the possible existence of intermetallic phases in the different weld regions where the black and light gray colour may indicate the presence of intermetallic secondary phases, while the white colour may be associated with the chromium depletion regions [18].

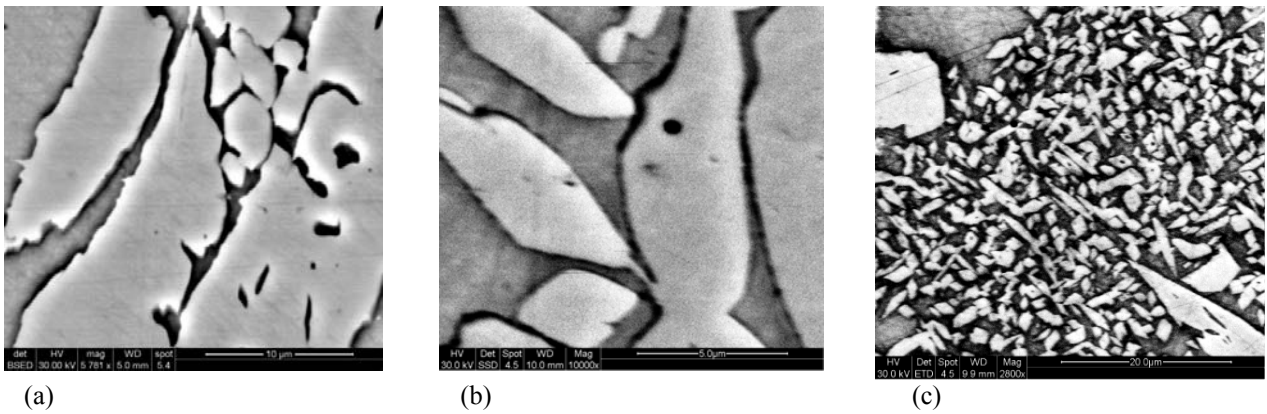


Figure 6 SEM images showing microstructure of the various weld regions; (a) lower weld pass region; (b) upper weld pass region; (c) coarsened areas at the weld top pass region

The absence of any secondary phases in the base metal, as suggested by the SEM image in Figure 4, suggests that the base metal can be classified as non susceptible to sensitisation and is therefore treated as the unsensitised region for the purpose of optimising the DLEPR test parameters.

Although secondary phases were not accurately identified using EDXS analysis, due to the lack of resolution available for determining chemical compositions of secondary phases, the back scattered electron images as shown in Figure 6 strongly support the existence of intermetallic phases. These appear as gray spots and black areas located in secondary austenite or at ferrite/austenite grain boundaries creating chromium depletion regions (white colour). The microstructures observed provide support for considering the weld joint to be treated as sensitised regions when considering optimisation of the DLEPR test [18].

3.2 DL-EPR Test Results using Conditions for 2205 DSS

As an initial test on the sensitised weld region, experimental conditions were employed that were optimised to suit 22% Cr DSS, namely 0.5 M H₂SO₄ + 0.001 M TA at 70 °C [1]. Under these conditions the DLEPR plot shows no reactivation peak (i.e., $I_r / I_a = 0$) as shown in Figure 7.

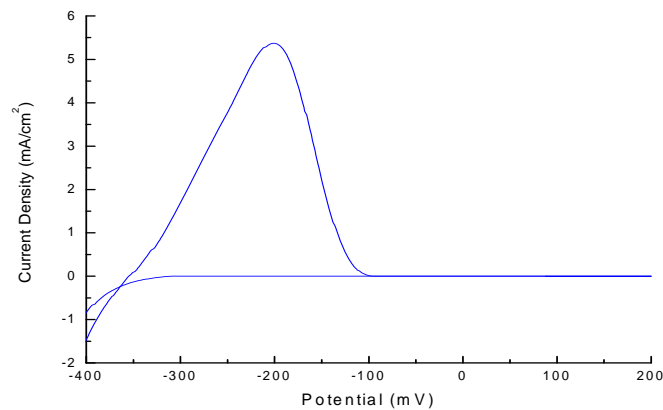


Figure 7 Plot of DLEPR test of sensitised weld region using 0.5 M H₂SO₄ + 0.001 M TA at 70 °C.

This confirms that these test parameters are not suitable for SAF 2507 and therefore a systematic investigation into optimizing different test variables such as electrolyte concentration, temperature, and scanning range was carried out.

3.3 DLEPR Test Results for Optimizing H₂SO₄ Concentration

DLEPR tests were conducted using different H₂SO₄ concentrations of 20% (v/v) and 10% (v/v), while keeping all other variables constant (0.001 M TA; 70 °C). The results are shown in Figure 8.

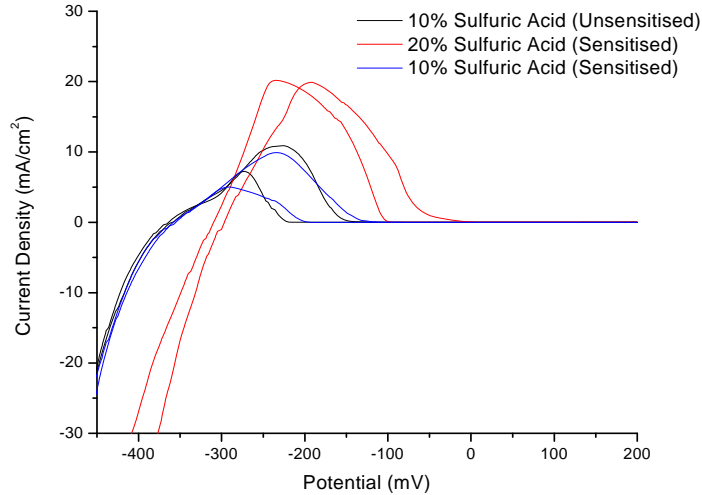


Figure 8 Plot of DLEPR test of sensitised/unsensitised regions using different concentrations of sulphuric acid +0.001 M TA at 70 °C.

It can be seen that for the electrolyte containing 20% (v/v) H₂SO₄, an I_r/I_a ratio equal to 1 indicates that general corrosion has occurred during reverse scanning, not IGC [3]. This suggests that the electrolyte is far more aggressive than required to give a reasonable degree of sensitisation. For the electrolyte containing 10% (v/v) H₂SO₄ a much lower reactivation peak was observed for both weld joint (sensitised) and base metal (unsensitised). It was expected to see a reactivation peak for the weld joint due to sensitisation, however, the appearance of a reactivation peak for the unsensitised base metal indicates the presence of other corrosion mechanisms occurring. OLM images of the base metal (Figure 9) suggests the occurrence of pitting corrosion which rules out these test parameters as being applicable for accurately determining the degree of sensitisation.



Figure 9 (a) OLM Image of SDSS unsensitised region after conducting DLEPR test using 20% H₂SO₄ in 0.001 M TA at 70 °C

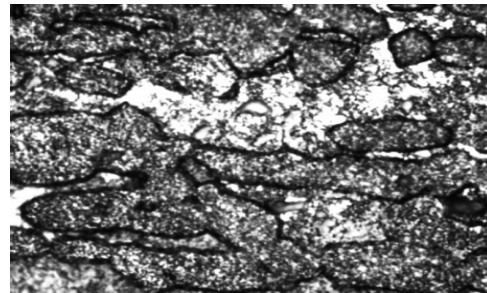


Figure 9 (b) OLM Image of SDSS unsensitised region after conducting DLEPR test using 10% H₂SO₄ in 0.001 M TA at 70 °C

3.4 DLEPR Test Results for Optimizing Thioacetamide Concentration

Given the improvement in the DLEPR responses at the lower sulphuric acid concentration, further tests were conducted at this concentration on the unsensitised base metal using different concentrations of the depassivator TA at 70 °C. Illustrated in Figure 10 are DLEPR experiments carried out with TA at a concentration range of 0.001 to 0.010 M TA. At higher concentrations of TA (0.005 M, 0.01M) an I_r/I_a ratio of nearly one was observed due to the occurrence of general corrosion processes as opposed to IGC only. It is also interesting to note the appearance of a second reactivation peak at -260 mV suggesting separate forms of corrosion. This was confirmed by the OLM images of the tested specimens, where pits and transgranular cracks were clearly observed (Figure 11). At a TA concentration of 0.001 M an I_r/I_a ratio suitable for studying sensitisation was observed.

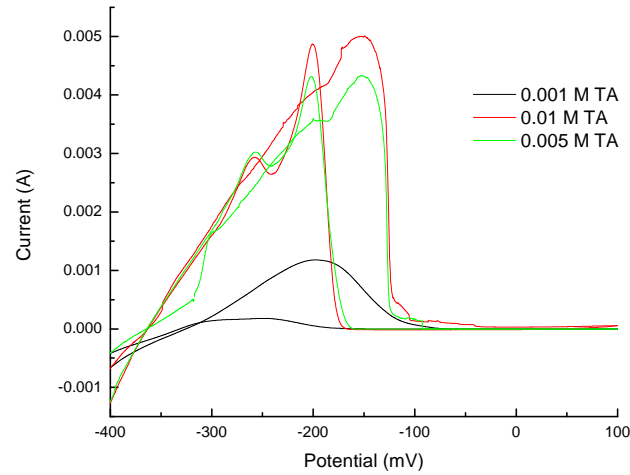


Figure 10 Plot of DLEPR test of unsensitised region using different concentration of TA + 10 % sulphuric acid at 70 °C.

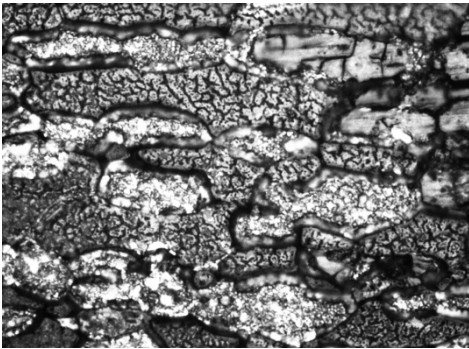


Figure 11 (a) OLM Image of SDSS unsensitised region after conducting DLEPR test using 0.005M TA in 10% H₂SO₄ at 70 °C

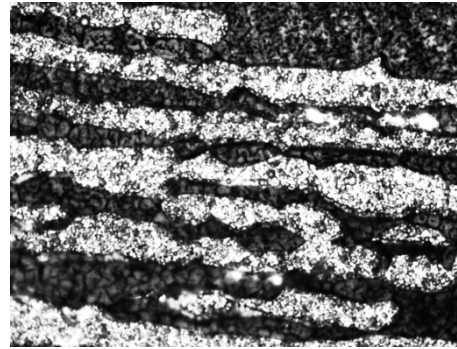


Figure 11 (b) OLM Image of SDSS unsensitised region after conducting DLEPR test using 0.01M TA in 10% H₂SO₄ at 70 °C

3.5 DLEPR Test Results for Optimizing Temperature

The final experimental parameter that can be tuned to give a reliable protocol for DLEPR testing is temperature. Therefore, DLEPR tests were conducted using 10% sulphuric acid + 0.001 TA at different temperatures (60, 65, and 70 °C) on the unsensitised base metal and at 70 °C on the sensitised (weld) region. The observed I_r/I_a ratio was higher than for the test conducted at 70°C and 65 °C on the unsensitised base metal, while at 60 °C no reactivation peak appears ($I_r/I_a = 0$) when the test was conducted on the unsensitised base metal and the sensitised weld joint (see figure 12). This indicates that the optimum temperature is somewhere between 60 °C and 65 °C.

The DLEPR test was then conducted on the unsensitised base metal and sensitised weld joint using 10% H₂SO₄ + 0.001M TA at 63 °C (see Figure 13) which shows $I_r/I_a < 1\%$ for the base metal (unsensitised) and $I_r/I_a > 1$ for the weld joint (sensitised). This indicates that the test conditions are now optimised for measuring the degree of sensitisation of AISI 2507 SDSS and its susceptibility to IGC.

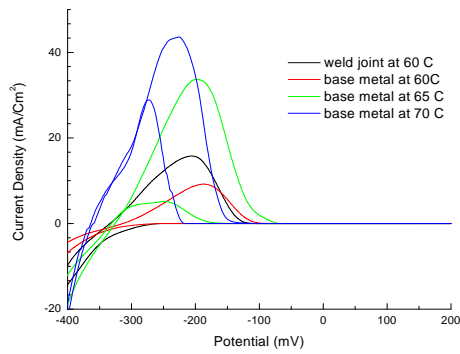


Figure 12 DLEPR results for base metal and weld joint using 10% H₂SO₄ + 0.001 TA at different temperatures

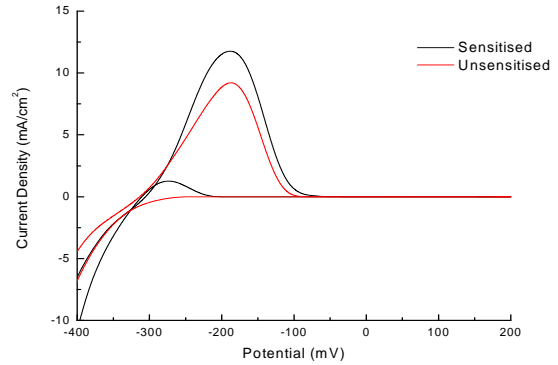


Figure 13 Plot of DLEPR test of unsensitised/sensitised regions using 10% sulphuric acid + 0.001 TA at 63°C.

OLM images of samples subject to DLEPR testing under optimised conditions (10% (v/v) H₂SO₄ + 0.001M TA at 63°C), for both unsensitised and sensitised regions, show intergranular attack at the grain boundaries in the sensitised regions with the complete absence of any other form of corrosion (see figure 14) which confirms the validation of the modified DLEPR optimised for AISI 2507 SDSS.



Figure 14 (a) OLM Image of AISI 2507 SDSS tested specimen using optimised DLEPR conditions showing sensitised region

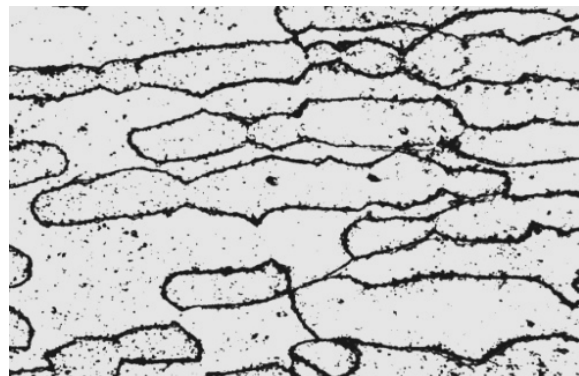


Figure 14 (b) OLM Image of AISI 2507 SDSS tested specimen using optimised DLEPR conditions showing unsensitised region

3.6 DLEPR Test Results for Optimizing Passivation Potential

Studies conducted on variation in the passivation potential revealed that the anodic passivation potential was also critical for conducting DLEPR tests on AISI 2507 SDSS. This is illustrated in Figure 15, which shows the influence of the upper scan limit on the reactivation process for unsensitised samples. The DLEPR plots show that when the potential is scanned to +100 mV, insufficient passivation occurred, resulting in the formation of a high reactivation peak. In contrast complete passivation of the unsensitised regions was observed at +200 mV.

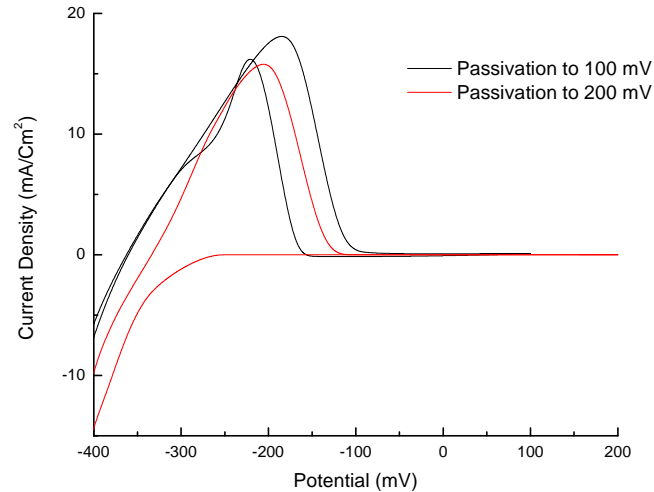


Figure 15 Plot of DLEPR test using 10 % sulphuric acid + 0.001 TA at 63°C for different scan range (passivation potential).

3.8 General Discussion on the DLEPR Tests Conducted

The results presented here show the validity of using the DLEPR test for evaluating the degree of sensitisation of AISI 2507 SDSS. As suggested previously for DLEPR testing, the test parameters have to be carefully optimised for each specific material studied. This is indicated by the failure of the test parameters employed for DLEPR testing of SAF 2205 steel on AISI 2507 SDSS. However, modification of those test parameters using the same electrolyte components but at different compositions allowed for a reliable test protocol to be developed. Specifically, under conditions of high sulphuric acid concentration (20 % v/v) large Ir/Ia ratios were found even for the unsensitised base metal which for the viability of this test should be less than 1 %. It was found that this electrolyte medium was far too aggressive and resulted in widespread pitting corrosion of the surface (Figure 9). Decreasing the sulphuric acid concentration to 10% v/v resulted in the occurrence of significantly less general corrosion. A critical parameter in the optimisation of the DLEPR test is the role of the depassivator. In this study TA was used which when employed at concentrations of greater than 0.001 M resulted in Ir/Ia ratios significantly higher than 1 % for the unsensitised base metal where the reactivation process was characterised by the presence of extensive pitting corrosion (Figure 11). When the concentration of TA was reduced to 0.001 M the extensive pitting of the base metal was alleviated. The optimum efficiency and sensitivity of the H₂SO₄ and TA electrolyte was found by tuning the temperature of the electrolyte. At a temperature of 60 °C no reactivation process was observed on the sensitised weld region and at the higher temperature of 70 °C a reactivation peak was observed for the unsensitised base metal. The optimum temperature for this test was then found to be 63 °C. It was also found that the anodic potential limit also played a role in the optimisation of the test parameters for DLEPR testing. If the anodic potential limit was only extended to 100 mV then a reactivation peak appeared at the unsensitised base metal indicating incomplete passivation of the surface. Therefore, to ensure complete passivation of the surface an anodic limit of 200 mV must be employed for this test.

4. CONCLUSIONS

A reproducible DL-EPR test method was successfully developed to characterize the degree of sensitization in super duplex stainless steel grade 2507.

Optimised conditions determined from this study for studying sensitisation were found to be 10% (v/v) H₂SO₄; 0.001 M thioacetamide and temperature of 63 °C.

Under optimised conditions, this DL-EPR test stimulated the most favourable selective attack conditions for studying sensitisation, without inducing other forms of corrosion such as pitting or general corrosion.

The sensitive nature of this test could lead to its future widespread use as a fast, quantitative, and non-destructive technique for evaluating the IGC sensitization of super duplex stainless steel components, even with minimal chromium depletion.

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6. REFERENCES

1. B Gideon and L Ward, Intergranular corrosion and residual stress determination of a duplex stainless steel pipeline girth weld (In) Proc. Corrosion & Prevention. Nov 16-19, 2008, Wellington, New Zealand, Paper 110
2. Badji R, Bouabdallah M, Bacroix B, Kahloun C, Belkessa B and Maza H, Phase transformation and mechanical behavior in annealed 2205 duplex stainless steel welds *Materials Characterization*, 59 (4) (2008) 447-453
3. Deng B et al, Application of the modified electrochemical potentiodynamic reactivation method to detect susceptibility to intergranular corrosion of a newly developed lean duplex stainless steel LDX2101, *Corrosion Science*, 52 (3) (2010) 969-977
4. Amadou T, Sidhom H and Braham C, Double loop electrochemical potentiokinetic reactivation test optimization in checking of duplex stainless steel intergranular corrosion susceptibility. *Metallurgical and Materials Transactions A*, 35 (3) (2004) 15
5. Bhattacharya A and Singh PM, Stress corrosion cracking of duplex stainless steels in caustic solutions, *Journal Failure Analysis and Prevention* 7 (5) (2007) 371-377,
6. Wen S, Lundin CD and Baten G, Metallurgical evaluation of cast duplex stainless steels and their weldments, Final report Vol. 1 submitted to US Department of Energy, Award Number - DE-FC36-00 ID13975, 2001
7. ASTM A262-81, Standard practices for detecting susceptibility to intergranular attack in austenitic stainless steels, ASTM, Philadelphia, PA, 1981
8. Baboian R (Ed), Corrosion tests and standards: application and interpretation (In) ASTM manual series, MNL 20-2ND, West Conshohocken, PA, ASTM International, 2004
9. V Čihal, A Desestret, M Froment and GH Wagner, On the development of the electrochemical potentiokinetic reactivation method - the EPR-test (In) Extended Abstracts of the 5th Conference of European Corrosion Federation Paris (1973), p. 249
10. ASTM G108-94(2010) Standard test tethod for tlectrochemical reactivation (EPR) for detecting sensitisation of AISI type 304 and 304L stainless steels
11. R Pederan and S Studholme, Experienced welding with cored wire 22% duplex and 25% super duplex stainless pipes (In) Duplex America 2000 Conference, (2000), Houston, Tx, pp 287-297
12. S Schultze, J Gollner, K Eick, P Veit and I Garz, The modified EPR test: A new tool for examination of corrosion susceptibility of duplex stainless steel (In) Proc. Duplex '97, 1997, The Netherlands, Paper D97-067, p 639.
13. Turnbull A, Francis PE, Ryan MP, Orkney LP, Griffiths AJ and Hawkins B, A novel approach to characterizing the corrosion resistance of super duplex stainless steel welds. *Corrosion (NACE)* 58 (12) (2002) Paper No 02121039
14. ASTM, A923-94, Standard test methods for detecting detrimental intermetallic phase in wrought duplex austenitic/ferritic stainless steels
15. Russell SW and Lundin CD, The development of qualification standards for cast duplex stainless steel, Final report, Vol. 2 submitted to US Department of Energy, Award Number - DE-FC36-00 ID13975, 2005
16. Gideon B, Structural characterisation, residual stress determination and degree of sensitisation of duplex stainless steel welds, Ph.D Thesis, School of Civil, Environmental, and Chemical Engineering, RMIT, 2009, p. 265.
17. ASTM, E562, Standard test method for determining volume fraction by systematic manual point count.
18. Magnabosco R, Kinetics of sigma phase formation in a duplex stainless steel, *Materials Research* 12 (2009) 12 7.

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