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Report on weld cleaning methods	15/8/2007	1
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Introduction

Cleaning of stainless steel weldments is particularly important in order to achieve adequate corrosion resistance after welding. Methods such as mechanical and chemical cleaning are typically used. Recently, electrochemical methods have also been employed where pickling pastes are considered dangerous for OH&S reasons.

An investigation has been conducted to assess the performance of various cleaning processes, including electrocleaning and determine their effects on the corrosion resistance of weldments in 316L stainless steel.

Cleaning of stainless steel weldments

Post weld cleaning of TIG welds on pipe joints has previously been evaluated by Fager (1). A summary of the test results for duplex stainless steel SAF2205 is given in Figure 1.

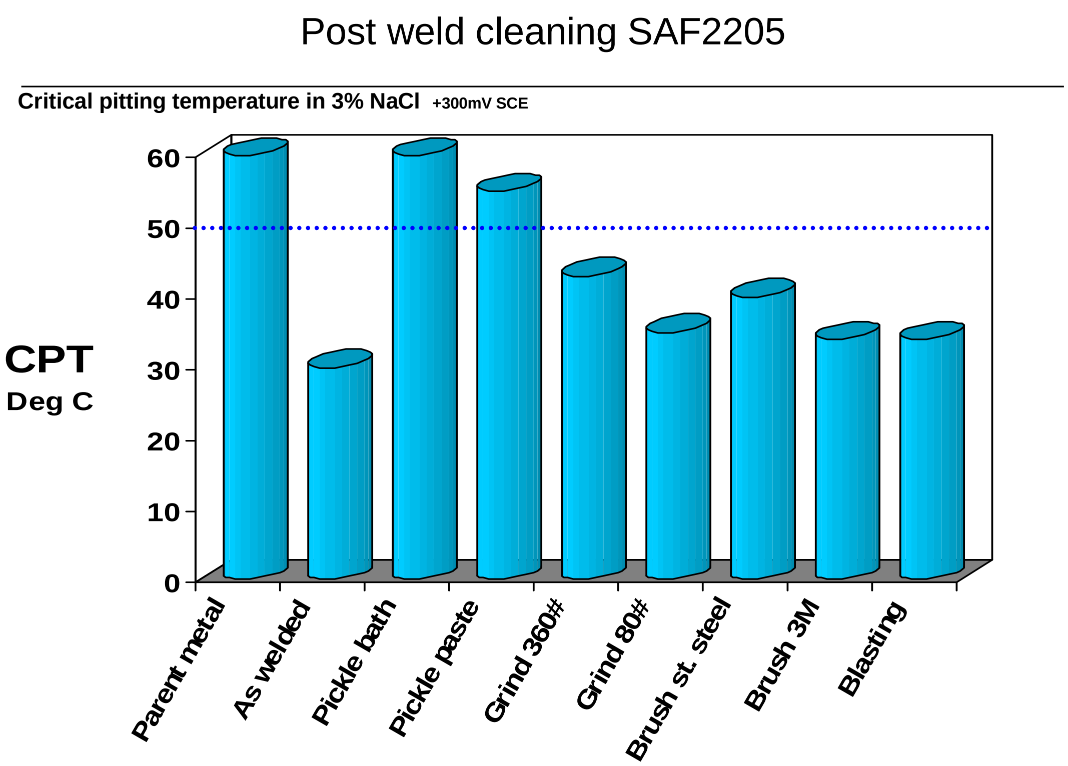

Figure 1. The effect of various mechanical and chemical cleaning methods on the pitting resistance of SAF2205 duplex stainless steel.

In general, the finer mechanical finishes return the surface corrosion resistance closest to that of the original mill annealed and pickled finish. Chemical treatments such as pickling, are effective in returning the surface to the original finish.

Distribition:

Weldments
The high temperature heat affected zones (HAZ) of weldments are considered (1) to be chromium depleted, with an attendant reduction in corrosion resistance. The surface oxidation and chromium depleted zone and interference colours are represented in Figure 2.

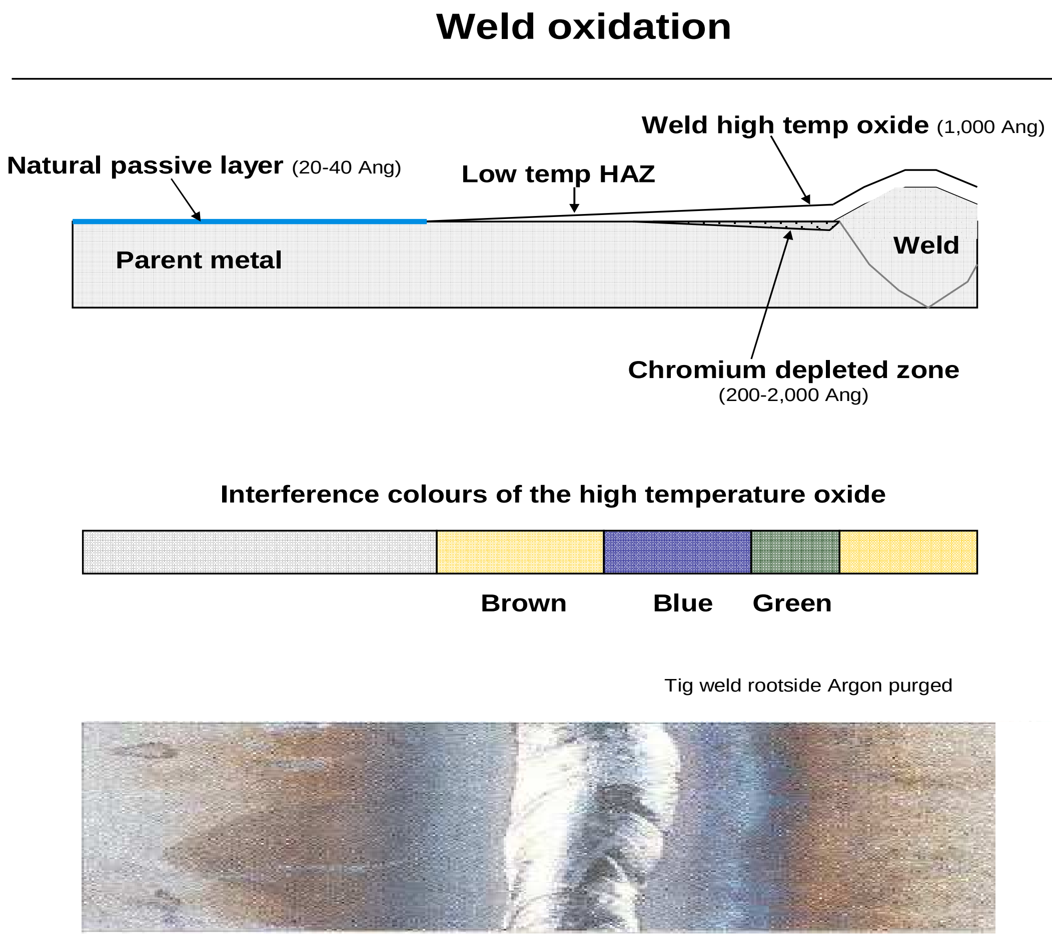

Figure 2. Surface oxidation, depleted zone and interference colours of stainless steel welds.

Testing program
This testing program was aimed at identifying the corrosion resistance of the different parts of the weldment, using some common methods of treating the welds. The material tested was standard 2B mill finish grade 316L stainless steel.

- Mechanical cleaning was conducted by buffing using a 3M scotchbrite pad.

- Acid cleaning was performed using pickling paste of 15% phosphoric acid and 0.9% Hydroflouric acid.

- Electrocleaning was performed using a portable electrochemical cleaning machine, using 20% phosphoric, and proprietary electrolyte solutions.

Electrochemical testing

Corrosion testing and evaluation was carried out using a portable electrochemical potentiostat (1), which allows easy access to virtually any size object with various surface geometries even on-site. This is particularly important in the case of weldments, where analysis of specific areas of the heat affected zone and weld metal produce different results.

Determination of the pitting potential used in these tests has been found (2) to be the most appropriate test method for standard stainless steel grades when compared with critical pitting temperature and critical chloride concentration methods.

The sensor makes electrolytic contact with the surface. Capillary forces cause electrolyte flow through a porous polymer pen.

By positioning the pen on the sample surface, electrolytic contact is established and electrochemical characterization is possible. The measured test area is 1.5 mm^2.

Fig 1: Electrochemical measurement of a stainless steel tube.

Electrolytes of 0.5M, 1.0M and 5.0M NaCl solutions are prepared from distilled water and reagent grade chemicals. All potentials are referred to saturated calomel electrode (SCE). Prior to testing the surface is cleaned with ethanol. The surface is locally contacted by the electrolyte and is controlled by an electrochemical control unit.

The instrument runs polarization scans at a rate of 10 mV/s in order to determine the pitting potential. A typical calibration measurement is shown in Fig. 3. Running several calibrations results in the averaging of the instrument of the determined pitting potentials.

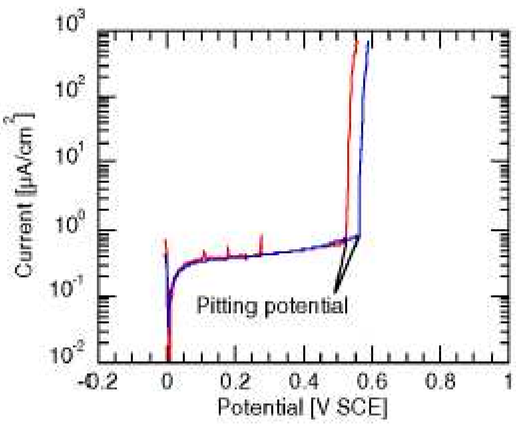

Fig. 3. Calibration scan determines pitting potential

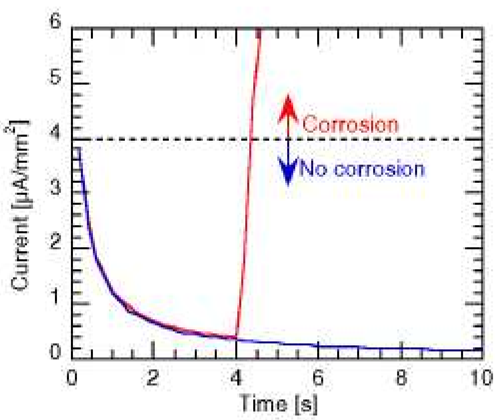

Fig. 4. Corrosion current at the reference potential

Once calibration is completed, the instrument decreases the potential by 120 mV. By running potentiostatic tests for 10 seconds, the relative corrosion resistance is determined. Typical results are shown in Fig. 4.

If the current shows typical passive behavior it can be concluded that the tested area exhibits a pitting potential that is comparable or higher than the area where the instrument was calibrated. If the current shows a strong increase, it can be concluded that pitting is initiated. Hence, the tested area exhibits a corrosion resistance that is significantly decreased compared to the area where the calibration was performed.

The above technique, as well as direct determination of the pitting potential, have been used to determine effectiveness of various processes for post weld treatment of weldments.

Test Results

Post weld cleaning methods

Corrosion tests were conducted on the parent metal, similarly treated parent metal, low temperature HAZ, high temperature HAZ and weld metal, after various forms of cleaning.

Automatic 316L MIG welds with argon purge on the rootside were used. Tests were conducted on grade 316L 2B material using 1M NaCl solution at 18 degC.

The test results are sumarized in Figure 5. Electrocleaning (a) was conducted with 20% phosphoric acid gives a similar result to that of pickling paste. The results shown here for electrocleaned (b) represent a proprietary electrolyte.

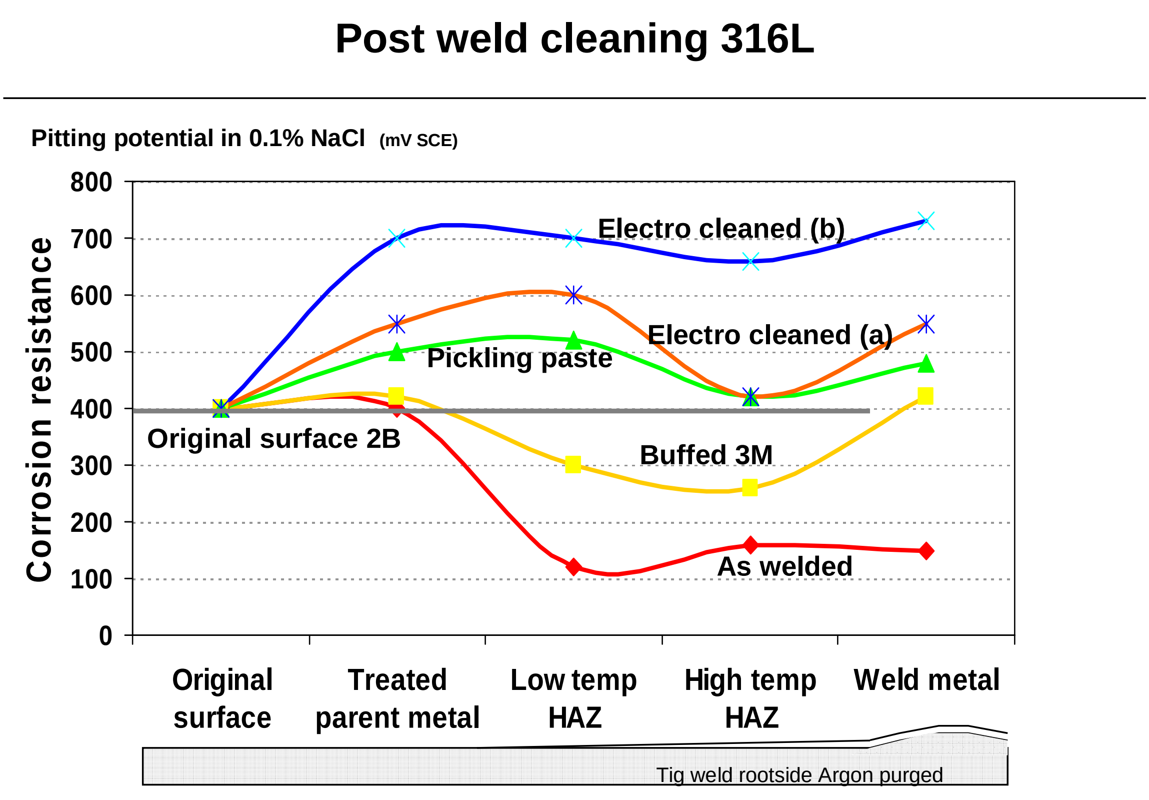

Figure 5. Effect of cleaning methods on a stainless steel weldment.

Weld cleaning

A separate set of tests were conducted to determine the pitting potential of the parent metal, HAZ and weldmetal on the root side of the weld. Measurements were taken before and after electrochemical cleaning of the welds. Testing was conducted on grade 316L 2B material using 0.5M NaCl solution at 20 degC. Results are given in Figure 6.

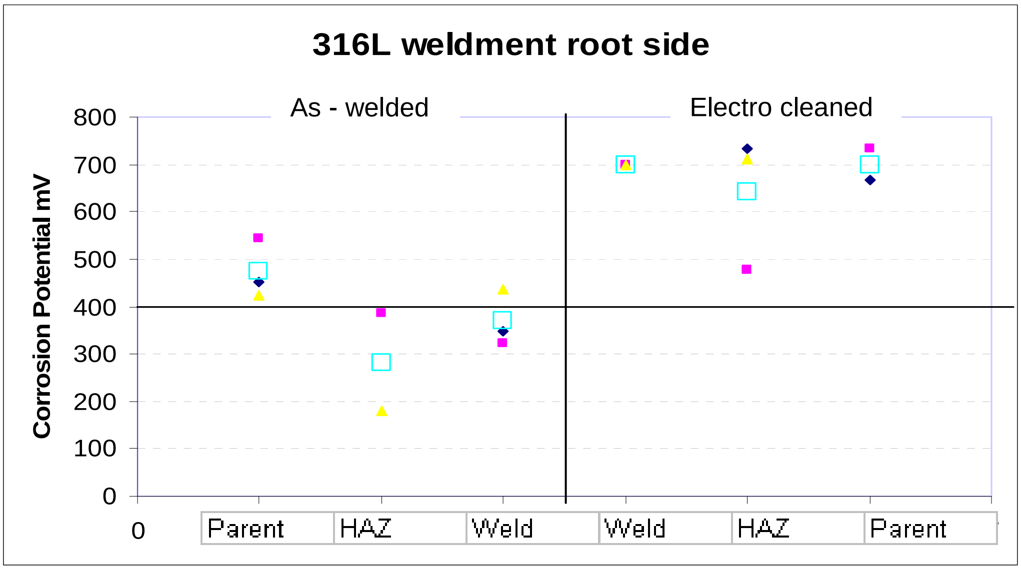

Figure 6. Showing the positive effect of electrocleaning on the root side of a weldment.

A similar result for electrocleaning was obtained by Büchler (4) who conducted a potentiostatic linescan over a weld of DIN 1.4301 (304L) (Fig. 7), which reveals the the initiation of local corrosion attack on the oxide layers of the heat affected zone.

These were removed and the surface passivated by an electrochemical treatment with ac-current on part of the sample surface. Then the scanning was repeated in a two dimensional scan showing the lateral distribution on the entire sample surface (Fig. 8). The result of the two dimensional scan demonstrates clearly that the lower left side of the sample which has been treated shows passive behavior, while the non treated upper right side shows pit initiation along the weld.

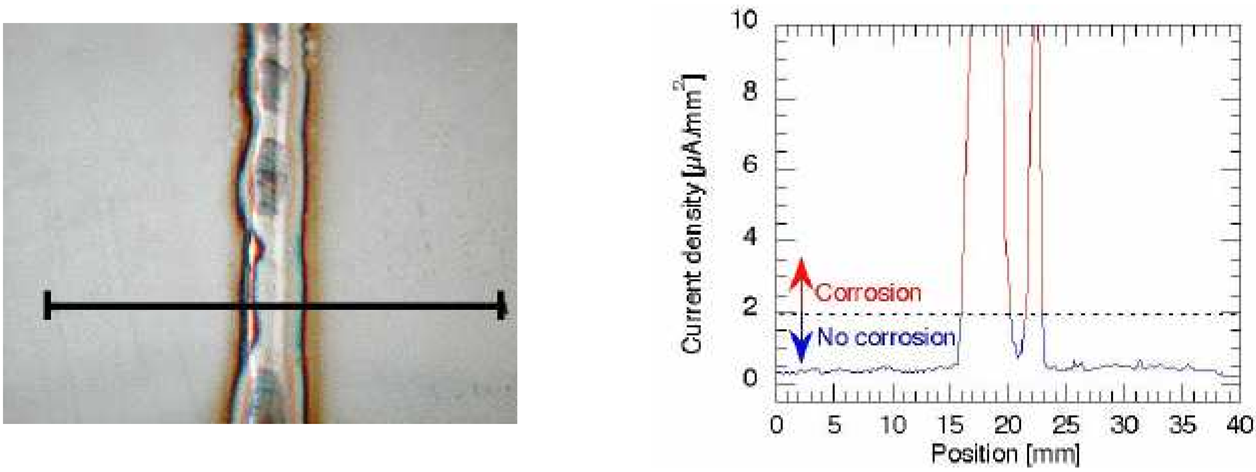

Fig. 7: Potentiostatic line scan (4) over a weld of a stainless steel (DIN1.4301) showing the variation in corrosion current of a 40mm test length. Tested in 0.1 M NaCl at 260 mVSCE.

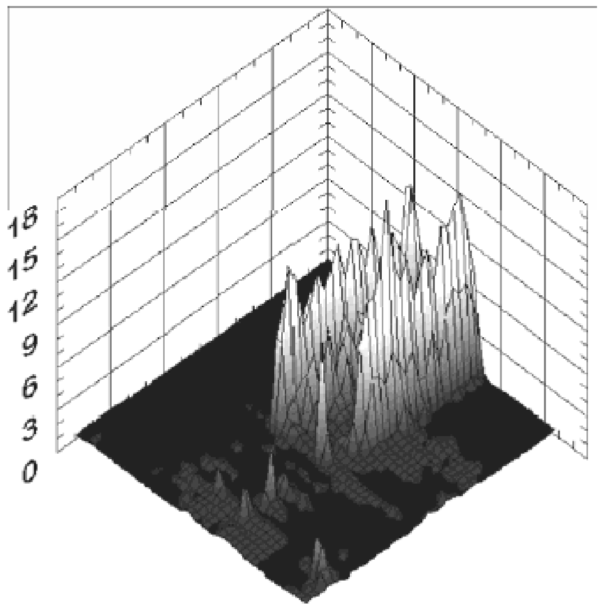

Fig. 8: Potentiostatic current [µA] distribution on a weld on DIN 1.4301 at 0.3 V SCE in 0.1 M NaCl over an area of 30 x30 mm. The lower left side of the sample has been electrocleaned showing passive behavior, while the non treated upper right side shows pit initiation along the weld. (4)

Conclusions

Pickling with commercial pickling paste significantly improves the corrosion resistance compared with that of the as-welded material. It was surprising however to observe that the corrosion resistance of both HAZ and weld metal approached, but did not quite match that of the parent metal.

The electrocleaning process not only recovered, but can improve the corrosion resistance to a level above that of the original parent metal. The results depended on the method and solution used.

It is concluded that electrocleaning is at least as good as pickling and can even improve the corrosion resistance of weldments. Further test work is planned to confirm and extend the scope of this evaluation.

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