CHARACTERIZATION OF JOINT WELDED BY TUNGSTEN INERT GAS (TIG) AUTOGENOUS STEEL PROCESS UNS S32707 SIMULATING A HEAT EXCHANGER FOR OIL HEATING

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1 Introduction

The hyper duplex steels have a biphasic structure, in the same proportion of austenite and ferrite. They are widely used because they have excellent mechanical properties and great resistance to corrosion in aggressive environments, such as in deep water and heat exchangers, in oil refineries. The study of this material is important because with its welding there is the possibility of the formation of undesired phases which would decrease the high resistance desired to it, so it is very important that it present its biphasic equilibrium under any circumstances. For this phase equilibrium to be maintained, chemical stabilization elements in each phase must be included. The inclusion of nitrogen is used to stabilize the austenitic phase and the ferrite phase is stabilized by the chromium element. [2] In welding TIG autogenous, which is the focus of this work, the biggest problems occur with the increased presence of ferrite, the formation of chromium nitride and the presence of deleterious phases such as sigma or chi which to cause increased hardness in the material, that do the corrosion resistance worsens. With the addition of nitrogen to the shielding gas, together with the argon, the austenite is not lost with the formation of the base metal.

This study analyzes the welding joints of hyper duplex steel UNS S32707 with two different amounts of nitrogen present in the protective gas, with the highest value being 5.5% in relation to the amount considered standard by the industry of 2.5% in the TIG welding process by measuring hardness profiles and SEM, EDS and EBSD techniques. There is also a study of the corrosion resistance of these welded joints through the mass loss corrosion test according to standard ASTM G-48 simulation working conditions of heat exchangers in oil refineries, where crude oil at high temperature is used.

2 Methodology

The base metal is a hyper duplex steel UNS S32707 type with biphasic austenitic-ferritic microstructure. The Autogenous TIG welding its purpose to simulate a pipe sealing conditions in heat exchanger. They have no addition metal and the sample as in seamless pipes, annealed.

Two samples with different percentages of nitrogen in the protection gas composition were studied. One with 2.5%, as usually used commercially and with 5.5%, considered an acceptable value for the phases to remain as in their original biphasic state. The Vickers (HV) microhardness measurements on welded joints tested was performed to determine if there have any variation in the mechanical properties of the samples between the critical regions: the base metal (BM) and fusion zone (FZ). The part of analysis microscopy was performed in SEM (Scanning Electron Microscope) and was realized to determine the present phases in the microstructure and for the possible to encounter possible undesirable precipitates. They occurred in two stages: one with low increase (up to 1000X) and large increase, respectively. The EDS (X-Ray Energy Dispersive Spectroscopy) is used for semiquantitative analysis of the chemical elements present in the samples. The Vickers microhardness and the analysis in microscopy was done together with the doctoral thesis of André Pimenta. [3]

The technique of EBSD (Electron Backscatter Diffraction) allows the determination of orientations and phase compositions of any plane or crystallographic direction. The corrosion testing with working fluid (crude oil) are performed according to ASTM G48 – 99 [1] method A - mass loss corrosion test in working temperature of 220 °C. For established this temperature, a study was realized with a schematic of the petroleum distillation line and was chosen the worst scenario.

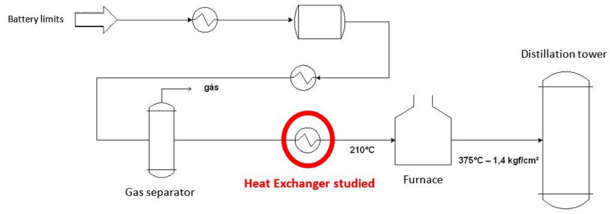

Figure 1: Schematic of the petroleum distillation line. The heat exchanger is located in the indicated area. Working temperature is 210 °C.

3 Results

The Vickers microhardness measurement profile of the two samples is in a very similar range between them, with no differences. This proves that the inclusion of nitrogen in the base metal did not leave the sample fragile as expected. SEM results show well delimited ferrite and austenite phases for the two samples in the heat affected zone and do not present undesired precipitates as nitrides. The EDS was performed in both phases. No stranger elements were found in the original alloy, so there is no contamination of the metal base or welding process. In the EBSD results, two different techniques were applied: the SEM analysis and the phase compositions, shown in figures 4 and 5 respectively. Two different regions are indicated, one non-welded and welded. As well as the SEM result, the phases are well delimited and the percentage is very close in the biphasic microstructure.

SEM results:

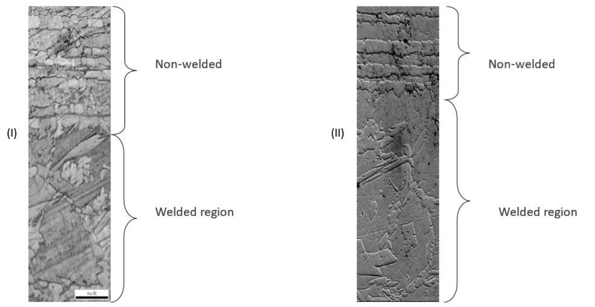

Figure 2: Comparison of the two welded regions together with the base metal (I) standard sample composed of 1.5% N; (II) modified sample composed of 5.5 % of N

Phase Composition:

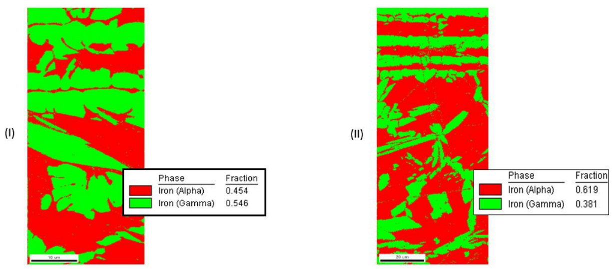

Figure 3: Comparison with respect to the composition of Ferrite (Red) and Austenite (Green) phases, with their percentages. (I) standard sample composed of 1.5 % N; (II) modified sample composed of 5.5% of N.

The corrosion test with the crude oil indicated good results showing no mass loss in high temperature. the corrosion test commonly performed for stainless steels (according to ASTM G 48 - method A and temperature effect) was not adequate to evaluate differences in corrosion resistance between the different types of welded samples, since the results obtained were not consistent.

4 Conclusions

- Tests with the SEM and EDS have confirmed that addition of the amount of nitrogen in the shielding gas causes the amount of austenite to stabilize in the fusion zone. This proving what the literature indicates that the hyper duplex steel has a better resistance to corrosion ;

- The EBSD technique the test proved to be very effective and could be further explored and still used in other studies;

- The corrosion test of the type indicated in ASTM G 48 - method A, chosen for this study and carried out in the laboratory, did not indicate precise results and it is necessary to perform other types of corrosive tests for more conclusive results;

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