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Research Paper

Characterization of cracks of welded joint of ferritic stainless steel pipe AISI 430

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***ABSTRACT* :-** *This paper presented the main objective characterization of cracks in welded joints of ferritic steels, since these are considered one of the most serious types of discontinuities in welds of these steels. These discontinuities are formed when tensile stresses are developed in a fragile material, unable to plastically deform the absorbing it. High tensile stresses are created and developed in the weld region as a result of thermal expansion and contractions located (associated with non-uniform heating of the weld), the volume changes due to phase transformations and as a result of links between pieces being welded and the rest of the structure. To induce cracking of the sample Varestraint test was used, as well as to measure the fracture toughness testing we performed Charpy Impact. However, in this study we observed that microfissures solidification in HAZ (heat affected zone), cracks in the center of the weld cracking due to thermal expansion and overhead imposed by the test were prevalent in these steels AISI/ASTM 430 specification. There was also the toughness of the weld proved always above to the base material.*

Keywords:- *HAZ (heat affected zone), microfissures, Varestraint test, discontinuities*

I. INTRODUCTION

Although these steels usually present low weldability, its good corrosion resistance and low cost when compared to other stainless often outweigh its application[1].

The fragility and susceptibility in the weld region may stem from structural changes, absorption of harmful elements, subsequent changes in other manufacturing operations (heat treatment), or even in service. Problems of cracking in welding can occur in both steels as in non-ferrous alloys, with the cracks being located in ZF, the HAZ and the base metal.

The cracks can be macroscopic, up to several inches in length (macrocracks or microfissures) or be visible only with a microscope (microcracks).Another limitation of ferritic stainless steel is that it is difficult to perform tempers, since it hardly achieves its austenitizing, but they have but they show great strength and high ductility. Normally your weld is characterized by low ductility and toughness favoring thereby the solidification cracks[2].

Different cracking mechanisms may be associated with welding. Some of these occur for different materials and welding processes, others are more common for a particular type of material.

Cracking problems which occur during welding when the material is subjected to high temperatures, i.e., greater than half its liquidus temperature. As an example of this type of cracking can mention: cracking in the solidification, cracking in the HAZ and cracking due to loss of ductility (ductility-dip cracking).

These forms of cracking are commonly referred to, particularly in solidification cracking as hot cracking (hot cracking and high temperature cracking).

Others cracking problems occur during welding or shortly after the operation, when the material is subjected to temperatures below half its liquidus temperature, but will not be treated here[3].

II. EXPERIMENTAL PROCEDURES

Samples of ferritic stainless steel AISI 430 were analyzed in a spectrophotometer BRUKER-Q4-Tasman as specified in the Table 1 below.

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Table 1 - Chemical composition of ferritic stainless steel studied.

AISI/ASTM	C	Mn	Si	Cr	P	S
430	0.12	1.02	0.98	16.32	0.04	0.03

Samples of this steel plate weld and weldless were removed for toughness test [4] and posteriorly prepared metallographically to be observed under visualized using optical microscopy model LV150 Nikon with increased 500 times and to increases in precise observation of the cracks.

The gas tungsten-arc process (SMAW) was used with a conventional drooping characteristic dc rectifier. The test sequence was automatic[5].The samples were welded into thin sections 5 mm thick not influence much the toughness_and proceeded like the following layout of the figure1.

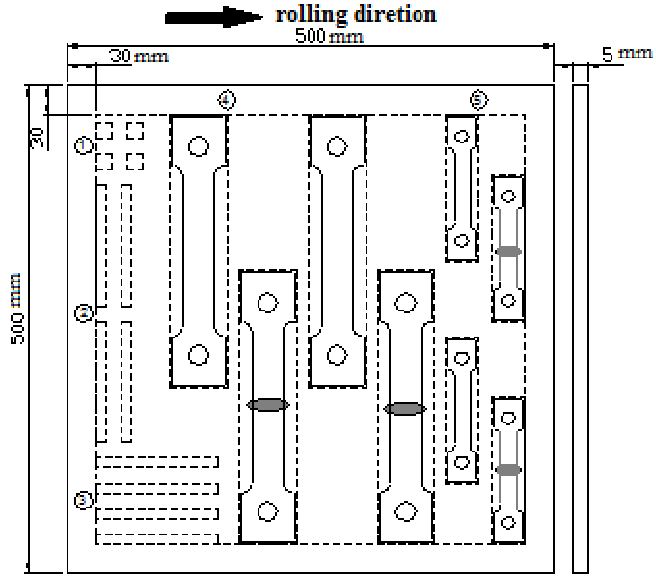

Figure 1 - Layout of the extraction of the specimens removed from the plate weld and weldless.

Aspects such as the influence of the chemical composition (nickel and chromium equivalent) of the weld or base metal as show figure 2 below, yet the welding parameters and stress levels were oriented although a crack tends to form and propagate complexly.

The process of arc welding was used SMAW with basic electrode FOX FFB of BOHLER WELDING, diameter 2.5 mm, low hydrogen, especially recommended for excellent resistance to hot cracking, although it is considered a good practice to limit the entry of heat with these steels to minimize grain growth (heat input 1KJ/mm and maximum interpass temperature 100-120°C) which implies that high deposition rate[6].

The pre-heating was not necessary since the thickness was of 5 mm. The said electrode FOX FFB is recommended the austenitic type 310, just to ensure that any dilution that occur, does not result in a austenitic/ferritic/martensitic very low ductility of the weld metal structure.

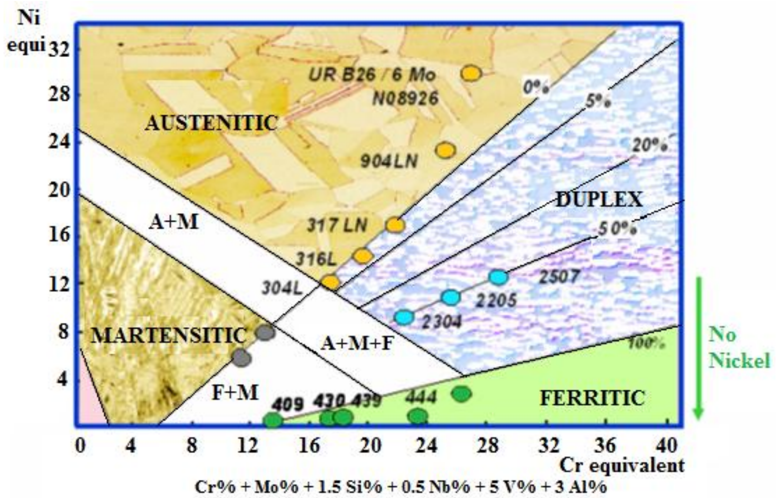

Figure 2 - Schaeffler Diagram for Stainless Steels

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Some tests are designed to evaluate a form of fine cracks in a given specific application. These tests attempt to reproduce an assembly generally small, the conditions existing in the welded structure of interest. Several tests provide only qualitative results (like "crack/no crack").

Others provide quantitative results, however these results can not directly be used to predict whether cracks may be formed during the welding of the real structure.

Despite these limitations, cracking tests are used in different applications, for example, including the selection of materials for welding, the development of a welding procedure, approval of welding consumables and more academic studies of the mechanisms controlling some form of cracking[7].

Welds were performed in single joints, and then broke into the draw to be able to examine the fracture surface and determine the presence of weld discontinuities, including cracks. Due to its simplicity, tests on simple joints are commonly required in manufacturing standards or specifications of welding consumables.

Another test evaluation is the self-restricted where a special joint used was able to generate in welding, transient and residual stresses leading to crack formation.

Also the external constraint test in which the request is imposed by an external device was applied with a load or controlled deformation to the specimen, during or after welding[8].

In the Varestraint test, a selected strain is applied to the sample during the course of welding as showed in the figure 2 below.

In this case, the strain is applied by bending at the point that the welding torch passes the point of contact between the sample and device adapted the WDW machine MC 100 E of 10tons, together with the application of welding.

Welding continues while the bending is implemented. Note that the strain is parallel to the welding direction. The extent of cracking observed is an indication of the sensitivity to hot-cracking.

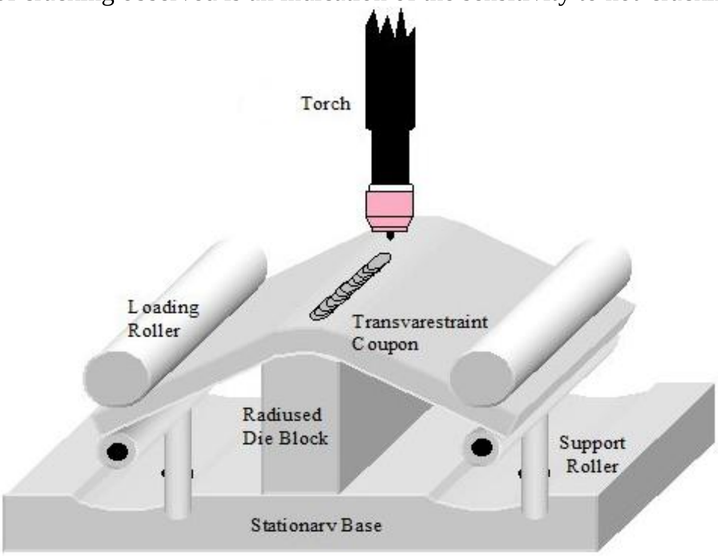

Figure 3 - Varestraint test device

III. RESULTS AND DISCUSSIONS

Micrographics analysis

Figure 4 shows a micrograph characteristic of ferritic stainless alloy with fully ferritic matrix with defined contours polygonal grains.

Figure 4 - Microcracks of a ferritc stainless alloy as received

However Figures 5 and 6 show photomicrographs were prepared after the Varestraint test, which respectively have microcracks in the HAZ solidification and crack at the center of the weld.
This shows that due to the loads, cracks originated due to increased fragility of the heat-affected region[8].

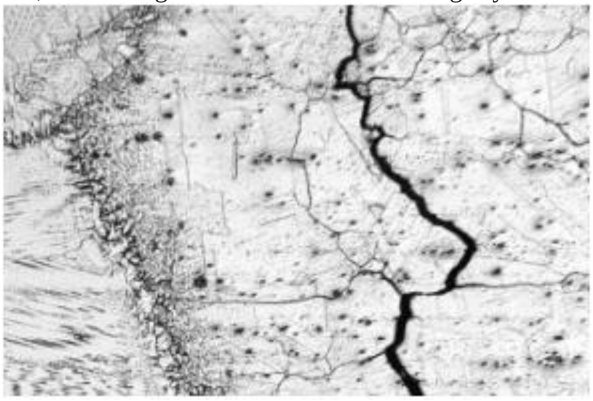

Figure 5 - HAZ microcracks solidification in a ferritc stainless alloy

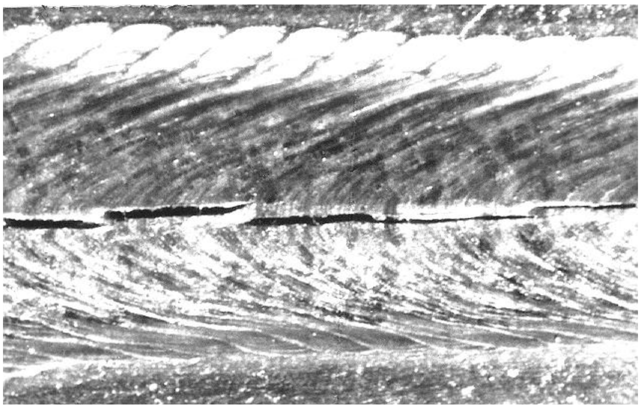

Figure 6 - Example of a crack in the center of the weld on the ferritic stainless

Toughness Test

The toughness tests were performed to observe only a defined difference in ductility between the region of the base metal and the weld precisely to define the cracks usually originate in the weld region most of the time[9].

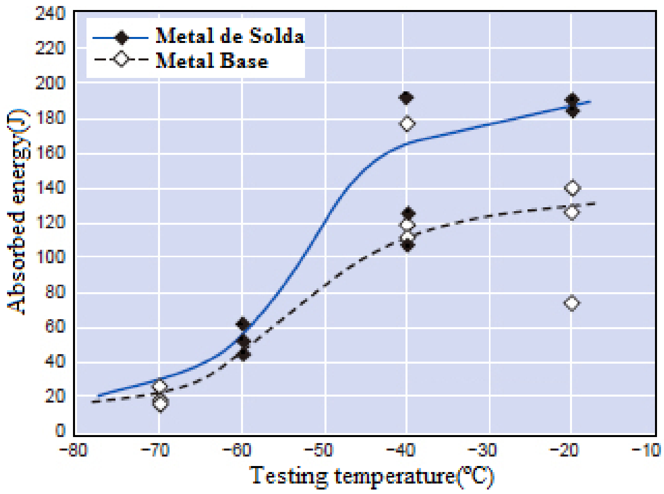

Figura 7 - Comparison of the toughness of the weld and weldless.

Figure 7 shows that the fragility was higher in the weld region because the region is the high incidence of intergranular cracks in these alloys.

IV. CONCLUSION

The Varestraint test has been shown to be a highly useful tool for exploring a particular facet of weldability, namely hot-cracking sensitivity. The challenge lies in properly interpreting the data within the limits of the test's usefulness, and in relating the data to real situations.

Useful and accurate estimates of the weldability of a material can be made when these relationships are defined. Extensive Varestraint testing of ferritc stainless steel show that:

1. The cracking-threshold strain value and the cracking response at low strain levels are the most significant indicators of hot-cracking resistance;
2. Weldability was characterized by the Varestraint test, has good correlation with actual welding experience for the alloy;
3. The weldability of alloy can be accurately predicted by the Varestraint test.

The cracks appear in the grain boundaries, boundaries interdentritics or between cells, i.e., the intergranular morphology is related to primary solidification structure. When the crack arises externally, the surface features are generally oxidized, reflecting its high forming temperature.

The cracks are generally longitudinal superficial, occurring often in the center of the bead, but may be transverse or radial and more specifically in the weld or HAZ region where ductility is lower.

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