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ANALYSIS OF COATING 410NIMO DEPOSITED IN THE CA6NM STEEL PROCESS BY WELDING COATED ELECTRODE

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Abstract. *Welding processes are used not only to join but also to coat components and parts, in some cases, to recover them. The present paper analyzes the coating of 410 Nimo martensiticstainless steel, in the form of a coated electrode, on the base metal of CA6NM martensiticstainless steel. A coating layer was deposited and the test was performed by Vickers microhardness tests and penetrating liquid. The results showed a coating with optimal dilution, high hardness and low porosity, showing that the coated electrode process can be an alternative for the deposition of this material.*

Keywords: *CA6NM, 410NiMo, Welding, Coated electrode, Coating.*

1. INTRODUCTION

The welding process usually generates changes in the microstructure and mechanical properties of the base metal, with the formation of harder and more fragile structures. These modifications alter the behavior to the nucleation and growth of fatigue cracks of the welded joint, as well as the fracture mechanisms involved in relation to the base metal (Pukasiewicz, 2008).

The molten martensitic stainless steels CA-6NM were developed with the aim of improving the weldability of martensitic stainless steels. The CA6NM steel, after tempering, presents excellent combinations of mechanical properties, such as resistance to deformation and erosion by cavitation and excellent toughness even at low temperature (Allenstein, 2007).

The 410NiMo has similar chemical composition to the CA6NM, causing that the microstructure of the base metal does not undergo major microstructural changes even after undergoing the welding process.

In this work, the welding process of coated electrodes was used as coating and recovery method for martensitic stainless steel CA6NM and consumable was the martensitic electrode ER410NiMo.

2. EXPERIMENTAL PROCEDURE

2.1 Base Metal

Base metal was used the martensitic stainless steel ASTM A743 CA6NM. The chemical composition thereof is shown in Table 1.

Table 1 – Chemical composition of base metal.

Chemical Composition								
CA6NM	C	Si	Mn	Cr	Ni	Mo	S	P
	0,03	0,30	0,45	13,0	3,7	0,34	0,003	0,02

2.2 Metal Addition Metal

The consumable for the coated electrode AWS ER410NiMo with a diameter of 2,5 mm. The chemical composition is shown in Table 2.

Table 2 – Chemical Composition of Coated Electrode.

Chemical Composition								
410NiMo	C	Si	Mn	Cr	Ni	Mo	S	P
	0,02	0,30	0,54	12,33	4,14	0,5	0,007	0,016

2.3 Welding Process

An electrode welding machine coated with Bambozzi Piccola 400C was used, as shown in Figure 4. The equipment has a voltage ranging from 220 to 440V. The current ranges from 40 to 80A. The machine must be grounded with a wire and must have a good contact with the metal case of the machine.

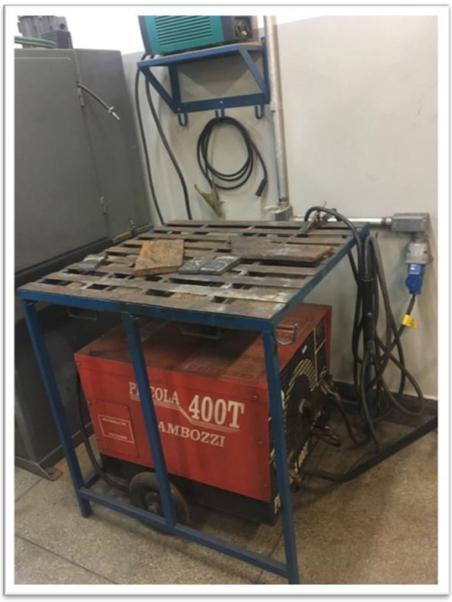

Figure 1. Coated Electrode Welding Equipment

For welding deposition, the coated electrode process was used with the parameters recommended by the manufacturer, according to Table 3.

Table 3 – Welding Parameters (Kestra Manufacturer)

Current (A)	70
Preheating Temperature (ºC)	130
Post heating temperature (ºC)	Room temperature

2.4 Penetrant Liquid Testing

After obtaining the welded samples, a visual test of Penetrant Liquids was carried out, following the PETROBRAS - N1596 standard, which aims to detect discontinuities on the surface of the material, both in the cross section and along the weld beads.

2.5 Metallographic Preparation

After completion of the coating, perform a metallographic preparation for analysis and mechanical testing. The welding material was then cut, embedded, sanded and polished and then submerged with the Vilela reagent.

2.6 Vickers Microhardness Test

The microhardness was measured at different points in the vertical section of the specimen, following the ASTM E384-05 standard, to analyze the differences between the coating, ZTA and the base metal, in order to evaluate the influence on the mechanical properties of the part. The equipment used in the process was the Microhardness HV - 1000B of the UTFPR Laboratory.

2.7 Optical Microscopy

An optical microscopy was performed to obtain images of the microstructure of the weld bead, the base material and the ZTA, to observe the difference between them. The images for analysis were collected using the Olympus BX51 microscope from the Materials and Surfaces Laboratory (LAMATS) of UFPR.

2.8 Porosity analysis

To quantify the coating porosity, the software Analysis 5.1, installed with the Olympus BX51 optical microscope software, from the Materials and Surfaces Laboratory (LAMATS) of UFPR, was used. Through the image captured by the microscope, an area is determined where, by color variation, the percentage of pores

3. RESULTS AND DISCUSSION

3.1 Penetrant liquid test

Through the penetrating liquid test, no surface cracks were observed in the coating, showing that the coating is suitable (Figure 2).

Figure 2. Samples after penetrating liquid test

3.2 Porosity analysis

Measurements of 5 areas were made for each sample and a mean of the results was performed. Table 4 shows the result.

Table 3 – Average Porosity

Sample	Average porosity (%)
1	0,7

The average porosity values of the coatings are low and lower than Olivio's (2016) literature.

3.3 Optical Microscopy Analysis

After the sanding and polishing processes, the sample was chemically attacked with Vilela for a better visualization of the microstructure. The image taken with the light microscope is shown in Figure 3.

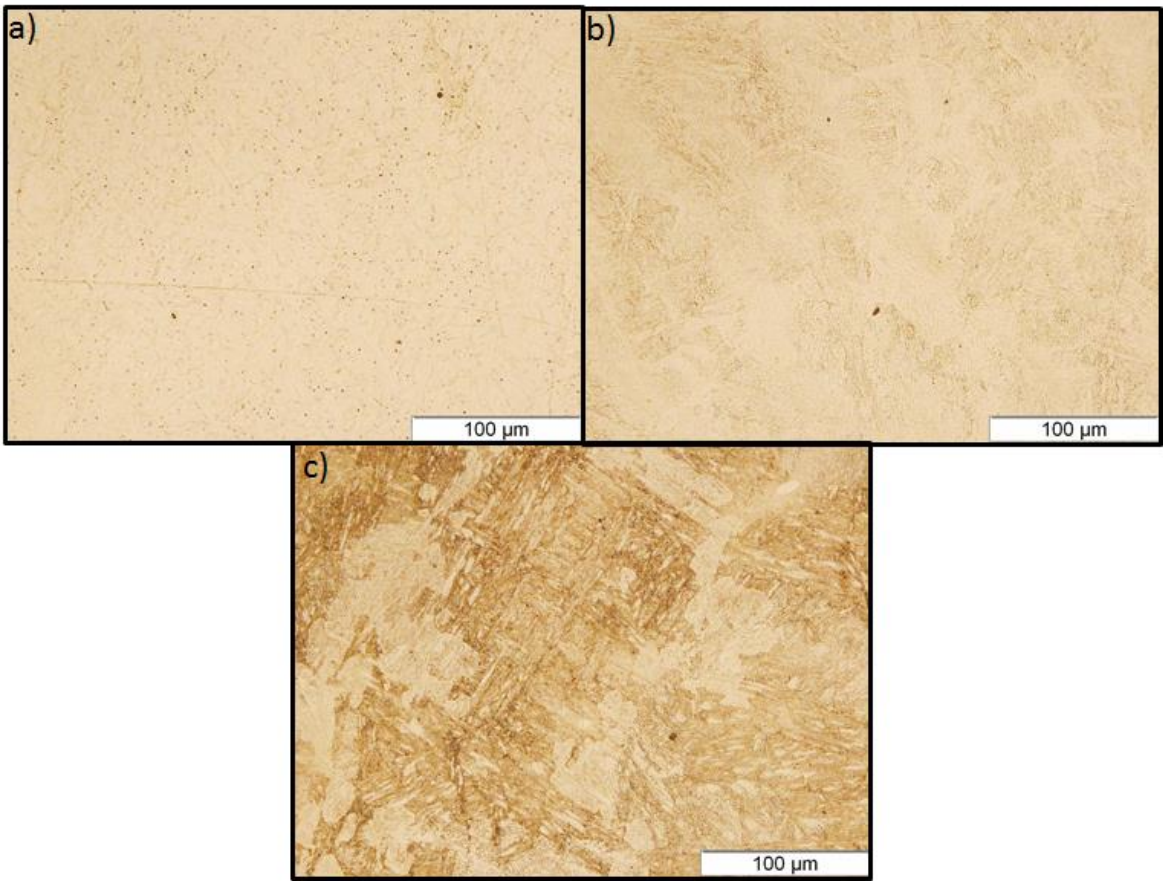

Figure 3. Microstructure through optical microscopy of the sample. a) Coating; b) ZTA and C) Base metal

The temperature of the welding process promoted a quenching treatment in the test bodies, refining the microstructure, of the zone affected by the heat in relation to the base metal. A martensitic and austenitic microstructure is present, it verified by the literature of Behene (2014) and Olivio (2016).

There is also repressed martensite, as shown in the image and is in agreement with the literature of Fernandes (2010). According to the author, the temperament of martensite increases tensile strength and ductility and, in some cases, without substantial reduction in mechanical strength. The high hardness and strength of the annealed martensite is directly linked to the high area ratio between the cementite and the grain contours.

3.4 Measures of Microhardness Vickers

The microhardness measurements were made in 3 columns of the part, in the vertical section (Figura 4). Measurements were made from the top of the coating to the end of the base metal, with approximately 0.13 mm and application of 300 gF for 15 seconds. The results are shown in Figure 5.

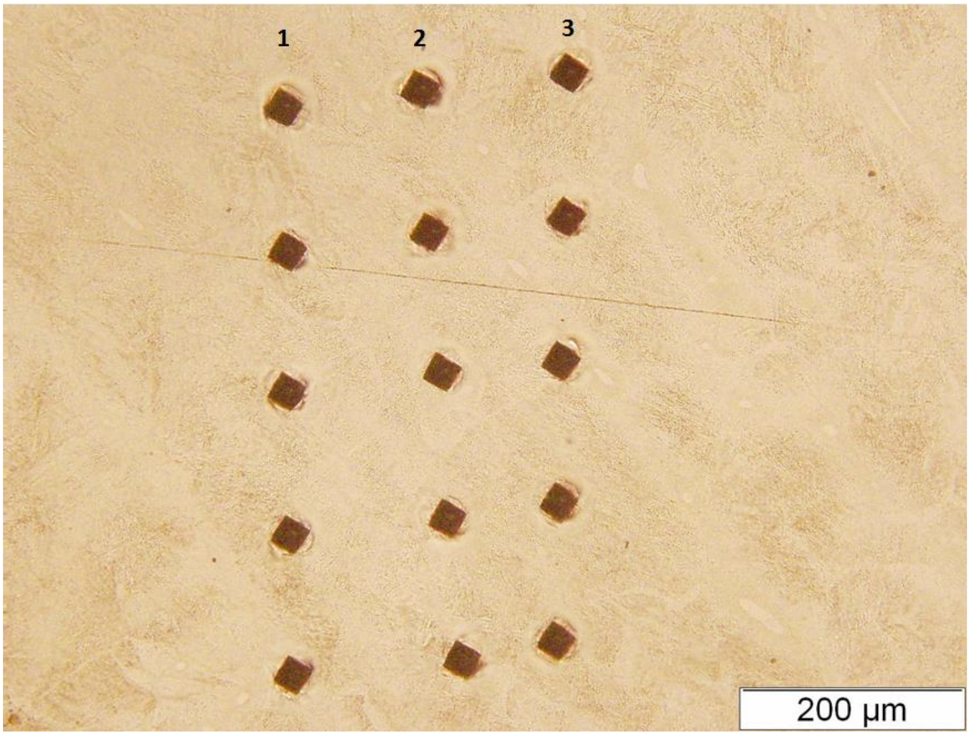

Figure 4. Vickers microhardness profiles

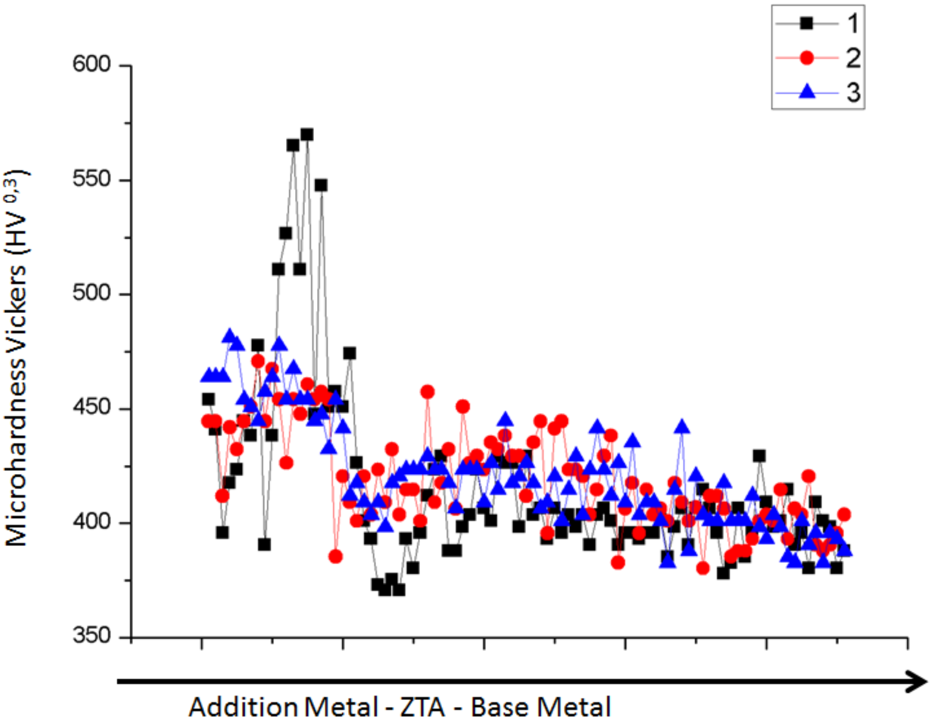

Figure 5. Microhardness in the vertical section of the coated test body.

It should be noted that there was no great variation of the hardness in the coating, ZTA and base metal. This ensures that the coating and the ZTA have mechanical properties similar to the base metal, in case it is necessary to recover some mechanical component, it can be guaranteed that it will not be weakened by the welding process. The hardness values are in agreement with the literature of Henke (1998), Pereira (2000), Capra et. Al (2007), Behene (2014) and Olivio (2016).

4. CONCLUSIONS

Observing the results of the tests of penetrating liquid and Vickers of microhardness and analysis of porosity and microstructure, one can conclude that:

• The coating remained intact without cracks or surface pores;

• The percentages of porosity are below the literature, showing that the coated electrode welding process obtained excellent dilution of the metal addition;

• Through optical microscopy, it is possible to notice a homogeneous coating with the refinement of the microstructure due to the welding process;

• The hardness values of the coating, ZTA and base metal are similar, ensuring the mechanical properties of the components and parts that need to be recovered;

• The hardness values are in agreement with the literature and have demonstrated a homogeneous coating that shows that the coated electrode process can be an alternative for the deposition of this material.

5. ACKNOWLEDGEMENTS

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7. RESPONSIBILITY NOTICE