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INFLUENCE OF COLD WORK BY TRACTION ON THE RESISTANCE OF 304L STAINLESS STEEL TO PITTING CORROSION

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ABSTRACT

The progressive deterioration of the mechanical characteristics generally frequents in the steel structures that work in present aggressive environment present a big worry for the researchers, especially in presence of mechanic solicitations, because the probability of failing that increases as the strain increases [1,2].

The aim of the present work was to clarify the effect of the cold work by traction on the pitting corrosion, of steel 304 L, in 30 g/l of NaCl environment. This study consists in submitting some specimens, gotten from the test-tubes of traction normalized and deformed to the different elongation rates: 2.18%, 3.63%, 10.90% and 16.36%, to the corrosion tests.

The experimental results of the different potentials of: corrosion, pitting and repassivation, have been compared and discussed according to the elongation rate. It was observed that all potential increases according to the increasing of elongation rate with the exception of the pitting potential or it has been decreased to the last elongation rate 16.36%.

KEY WORDS: 304L stainless steels, strain, traction, inclusion, pitting corrosion, potential.

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INTRODUCTION

Stainless steels are used largely to reason of their very good resistance to the uniform corrosion, due to the presence of a passive film in the surface, very thin and very protective. Among these steels, the austenitic alloys constitute a good compromise between good mechanical properties and an excellent resistance to the corrosion.

The understanding of the phenomenon of pitting corrosion is of as much more complex what requires multidisciplinary knowledges: mechanical, metallurgical and electrochemical [3,4,5].

The electrochemical behavior of 304L stainless steel in 30g/l of NaCl have been studied by many authors [6,7,8], but little that took in consideration the effect of cold working by traction to pitting corrosion [9,10,11].

EXPERIMENTAL

Specimen

The material used, in this work, was 304L stainless steel. Its chemical composition is represented in the table 1:

TABLE 1 - Chemical composition of AISI 304L (Wt %)

Cr	Ni	Si	Mn	Mo	C	S	P
18.78	8.80	0.45	1.34	0,27	0.06	0.008	0.01

The specimen first was machined into a tensile specimen (Fig.1) and then given predetermined strains of: 2.18%, 3.63%, 10.90% and 16.36% as shown in figure 2. The work was performed on 304L stainless steel plate, machined into 14 mm diam rod specimens.

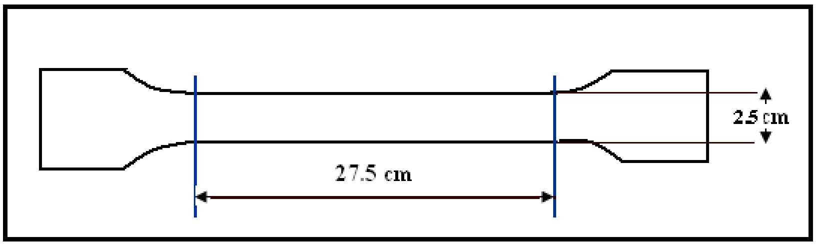

FIGURE 1. Tensile specimen dimensions.

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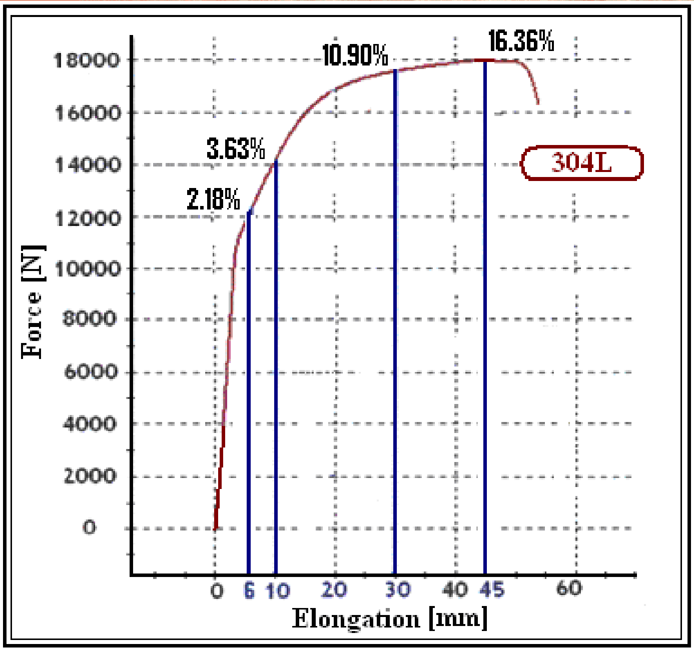

FIGURE 2. Conventional curve of steel 304L tensile

Corrosion test

The NaCl concentration of the test solution was 30 g/l. Before test corrosion the specimen were polished to a 1200 grit with emery papers and were degreased with acetone in an ultrasonic cleaner and washed with double distilled water.

The potentiocinetic method is used to determine the electrochemical characterization of stainless steels (304L), as corrosion potential, pitting potential and repassivation potential, in the aggressive environment [9,8].

RESULTS AND DISCUSSION

Hardness measure

The figure 2 represents the variation of the hardness according to the strain. The hardness increases with the strain increasing.

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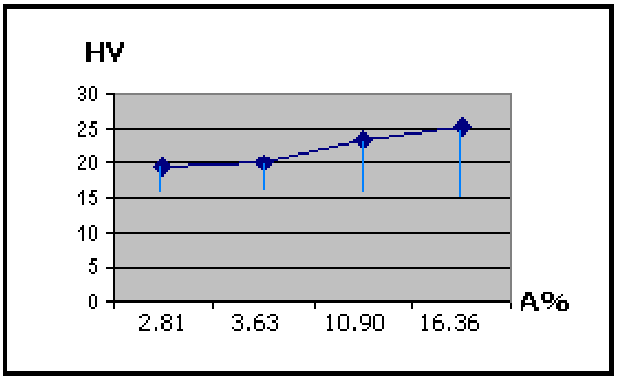

FIGURE 3. Hardness measure

Microstructure

In complement of the strain mechanisms described previously, we note that a cold work modifies the texture of 304L stainless steel; it provoked a change in the shape of the grains. During the tensile test and in the zone of plasticity, the grains **s'allonge** in the direction of tensile. We note that fragmentation in strips and in cells of dislocation has the effect of to modify the crystalline orientation and makes disappear progressively the individual character of the grains (Fig. 4).

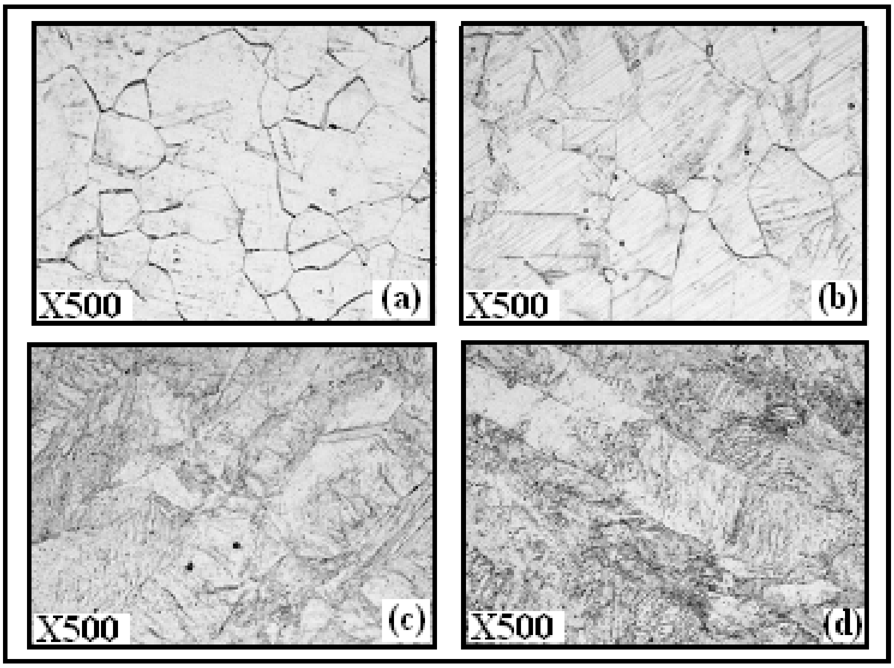

FIGURE 4- microstructure of 304L stainless steel: (a) 2.18%, (b) 3.63%, (c) 10.90%, (d)- 16.36%

Polarization curves Résults

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Polarization curves were obtained in 30g/l NaCl at temperature 24°C (±3°C). A sweep rate of 90 mV.mn^{-1} was used between -0.45 V and 0.9 V. In this work, corrosion potential, pitting potential and repassivation potential were principal parameters to study the effect of cold work on the resistance of 304L stainless steel to pitting corrosion.

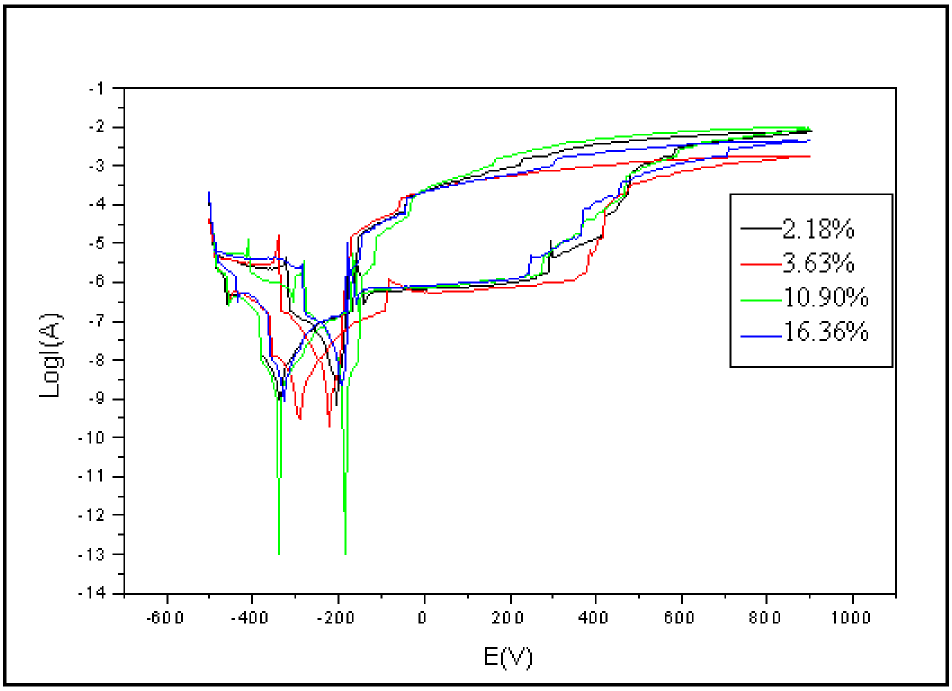

FIGURE 5. Polarization curves of 304L stainless steel in 30g/l NaCl

The pitting corrosion of 304L stainless steel is bound to the stability of the passive film. This stability takes in consideration the potential between metal and the solution. The figure 5 shows the variation of current intensity according to the potential. To the first contact with the solution, the specimen knew a fast dissolution, and then it knew a light variation of the current according to the time. The pitting corrosion occurs beyond 0.34 V, when the passive film pricked.

The formation of a hysteresis buckle that means the formation of pit (Figure 6), with a positive potential that shows that the formed film is stable.

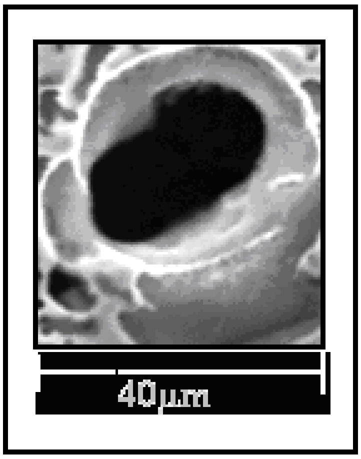

Figure 6- MEB image showing a pit on surface of 304L stainless steel.

Figure 7 shows an inclusion of MnS. To its neighbourhood, the passive layer is modified. This defect can play the role of a site of beginning of the pit on the passive film of 304L stainless steel [10].

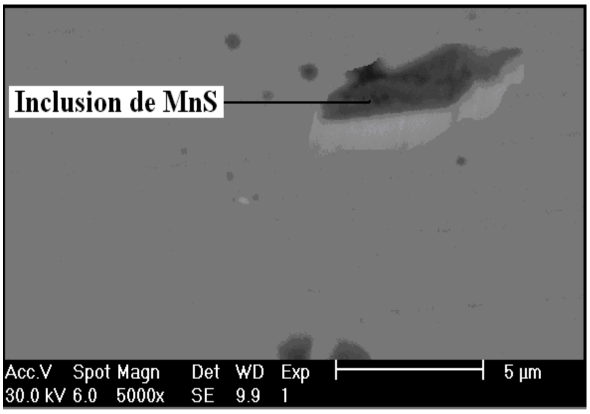

Figure 7- MEB image showing an inclusion of MnS

CONCLUSION

This study has been led in the aim to analyze the effect of cold work by traction, on the behavior of 304L stainless steel in 30 g/l of NaCl. Results gotten permit us to deduct the following conclusions:

- The progressive disappearance of the individual character of the grains when the rate of elongation reached 10.9%.
- The hardness of the 304L steel increased with the increasing of the elongation rate
- The presence of inclusion of MnS is a site favourable to a pit.
- The noblest corrosion potential corresponds to the weakest elongation rate.
- More the hardness increases the corrosion potential corrosion increases in absolute value.

- The pitting potential of 304L stainless steel has been decreased slightly to the last rate of elongation (E_p = 430.45 mV).

- The repassivation potential depends directly on the elongation rate. More the strain increases this potential more increases.

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