Journal of Engineering and Applied Sciences 3 (3): 221-224, 2008
ISSN: 1816-949X

The Effect of Tensile Deformation on the Corrosion Behavior of 304 L Stainless Steel in 3.5% NaCl Solution at Ambient Temperature

L. Yahia, M.H. Khireddine and E. Nouicer
Laboratory of Transformations of Phases, Department of Physique, Faculty of Sciences,
University of Mentouri, Constantine 25000, Algeria

Abstract: Austenitic stainless steels are the most popular metallic materials because their relatively low coast, ease of fabrication and reasonable corrosion resistance. The aim of the present research was to clarify the effect of tensile deformation, at ambient temperature, on the corrosion behavior of 304 L stainless steel in 3.5% NaCl solution. Electrochemical kinetic polarization technique was used to investigate the corrosion behavior in NaCl solution. The occurrence of pitting corrosion due to chloride ion attack was also examined by MEB. The experimental results show that corrosion potential increased by increasing the amount of deformation. The specimen deformed at 2.81% showed the best pitting potential or the best corrosion resistance. Increasing the deformation to 10.90% affect negatively the pitting potential. Arrived to 16.36%, the resistance corrosion was affected positively the corrosion resistance.

Key words: 304 L stainless steels, tensile, deformation, inclusion, corrosion resistance, potential pitting

INTRODUCTION

Stainless steels are used largely because of their very good resistance to the uniform corrosion, due to the presence of a passive film in 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 more complex what requires multidisciplinary knowledge: mechanical, metallurgical and electrochemical (Towie *et al*., 1981; Baroux, 1990; Salvago, 2002).

The electrochemical behavior of steel 304 L in 30g L^{-1} of NaCl have been studied by many authors (Burstein, 2004; Mudali, 2002; Hamdy, 2006), but little that took in consideration the effect of cold working by traction to pitting corrosion (Kain, 2004; Garcia, 2001).

This study deals with the modification of amount of deformation by tensile and its effect on the corrosion resistance in NaCl solution.

MATERIALS AND METHODS

The material used, in this research, was 304 L stainless steel. Its chemical composition is given in the Table 1.

Table 1: Chemical composition of AISI 304 L

Element	Cr	Ni	Si	Mn	Mo	C	S	p-value
wt.%.	18.78	8.80	0.45	1.34	0,27	0.06	0.008	0.01

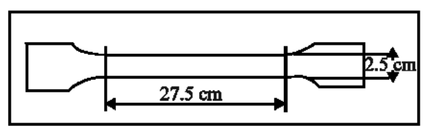

Fig. 1: Dimensions of the tensile specimen

The material underwent uniaxial tensile deformation at ambient temperature. the dimension of test pieces are 275 mm in length, 25 mm in width and 3 mm in thickness as shown in Fig. 1. Tensile tests were carried out by using ZWICK testing machine. The cross-head speed was 3 mm mn^{-1}. Each test was controlled to stop at different strokes in order to introduce different levels of deformation into the samples: 2.18, 3.63, 10.90 and 16.36% (Fig. 2), using the formula:

$$A\% = \frac{L_f - L_i}{L_i}$$

A% : Amount of deformation.
L_i : Initial length.
L_i : Final length.

Corresponding Author: L. Yahia, Laboratory of Transformations of Phases, Department of Physique, Faculty of Sciences, University of Mentouri, Constantine 25000, Algeria

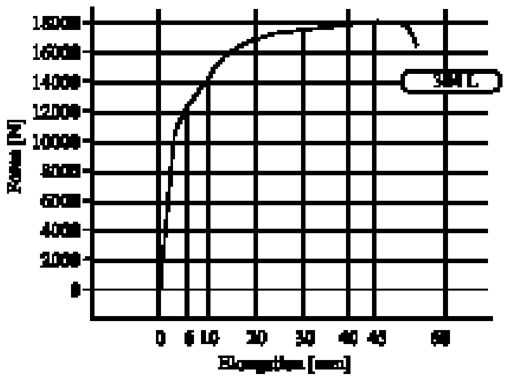

Fig. 2: Curve of fractured sample and the samples with different levels of tensile deformation at ambient temperature

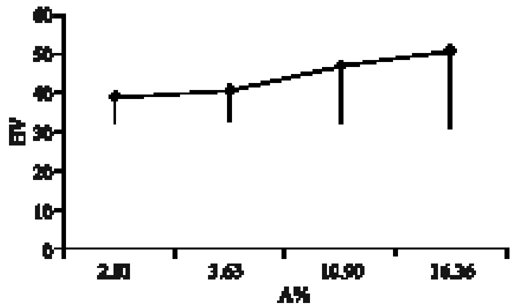

Fig. 3: Microhardness measurements

Surface preparation: After tensile deformation, small circular specimens of 1.1 cm^2 surface along the loading axial direction were cut by wire cutting from the central gauge part of samples for corrosion tests.

Series of specimens were abraded to 1200 finishes with SiC grit papers, than they were polished to a miror surface, followed by degreasing in an acetone solution, washed with distilled water and dried in dry air.

Microhrdness measurements: The Fig. 2 represents the variation of the Vickers micohardness test with 5 g load according to the deformation. The hardness increases by increasing the amount of deformation.

Microstructure: In complement of the deformation mechanism described previously, microstructures were observed with optical microscope.

Tensile deformation modified the texture of 304 L stainless steel; it provoked a change in the shape of the grains. 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 4a and b show the austenitic equiaxed grain structure with the presence of small islands of ferrite. In Fig. 4.c and b the martensite formation in heavily deformed austenite grains was remarked.

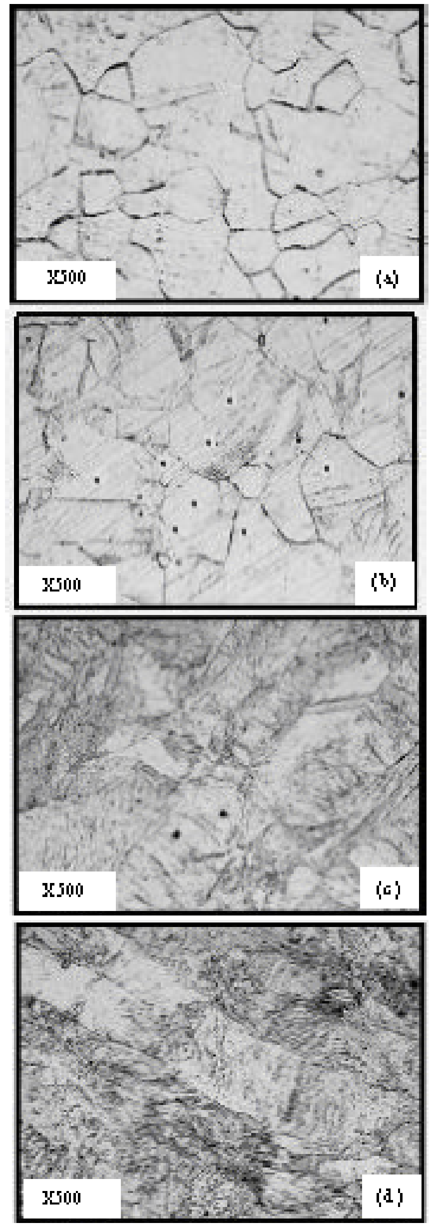

Fig. 4: Microstructure of 304L stainless steel: (a) 2.18%, (b) 3.63%, (c) 10.90%, (d)- 16.36%

Polarization tests: The potentiodynamic tests of specimens were made a scan rate of 100 mV.mn^{-1} in the applied potential range from -0.45 V_{sce} to 0.9 V_{sce} with respect to E_{corr} using EGG 83 galvanostat/potentiostat. The exposed surface area was 1.1 cm^2. All curves were normalised to 1cm^2.

RESULTS AND DISCUSSION

Electrochemical measurements have been used to investigate the corrosion behaviour of AISI 304 L in 3.5% NaCl at ambient temperature. The Fig. 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 breakdown.

The typical potentiodynamic results obtained show a wide passivity range characterised by a low passivity current of the lowed amount of deformation equal to 2.18% (Fig. 5).

The passivity breakdown potential E_b was evaluated performing chronoampermetric measurements at different potentials in the range of E_b singled out with the potentiodynamic experiments. Figure 6 shows that a passivity breakdown potential did display any dependence on the amount of deformation. The E_b at A% = 16.36 was slightly decreased.

But the repassivation potential did not really modified when the amount of deformation was increased (Fig. 7).

Figure 8 shows a shape of pit on surface of stainless steel. An inclusion of MnS is showed in Fig. 9. 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 304 L stainless steel (Towie *et al*., 1981).

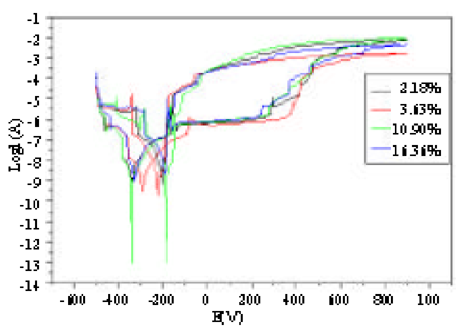

Fig. 5: Polarization curves of 304L stainless steel in 3.5% NaCl

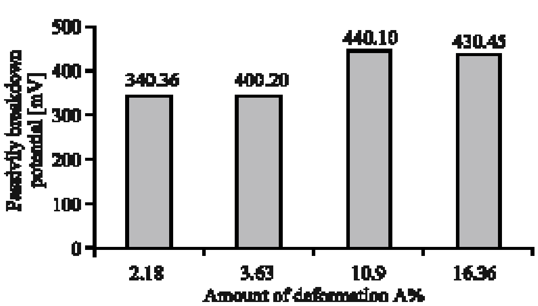

Fig. 6: Values of E_b for the different amounts of deformation

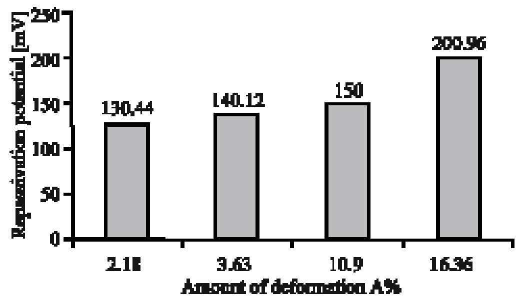

Fig. 7: Values of repassivation potential for the different amounts of deformation

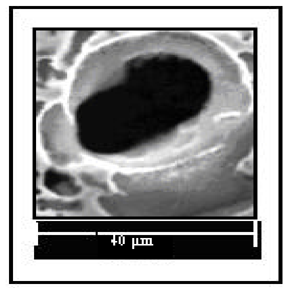

Fig. 8: MEB image showing a pit on surface of 304L

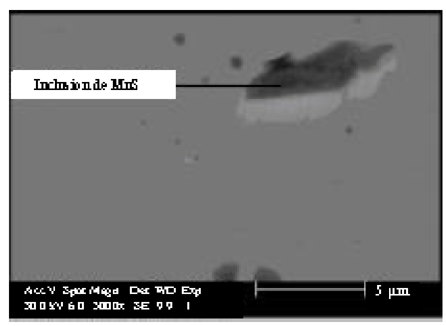

Fig. 9: MEB image showing an inclusion of MnS

CONCLUSION

Localized corrosion is a serious problem of stainless steels when they exposed to chloride solution and tensile deformed.

Tensile deformation has critical role on the corrosion resistance of 304L stainless steel.

At A% = A% = 16.36 this resistance was positively modified.

The best pitting corrosion resistance was obtained at 2.18% amount of deformation.

The repassivation potential did display any dependence on the amount of deformation.

REFERENCES

Baroux, B., 1990. Pitting Corrosion of Stainless Steels: The Important of Being a Metallurgist. LTPCM, INP Grenoble, France.

Burstein, G.T., C.R. Liu, M. Souto and S.T. Vines, 2004. Origins of Pitting Corrosion. Corrosion Eng. Sci. Technol., 39: 25.

Combrade, P., 1990. Corrosion sous Contrainte et Fatigue Corrosion. Les Edition de Physique, pp: 335-338.

Garcia, C., F. Martin, P.J. De Tiera, A. Heredero and M.L. Aparicio, 2000. Corrosion Sci., 43: 1519.

Hamdy, A., A.S. El-Shenawy and T. El-Bitar, 2006. The Corrosion Behavior of Nobium Bearing Cold Deformed Austenitic Stainless Steels in 3.5% NaCl Solution. Sci. Direct, 61: 2832.

Kain, V., K. Chandra, K.N. Adhe and P.K. De, 2004. Effect of Cold Work on Low Temperature Sensitization Behaviour of Austenitic Stainless Steels. J. Nuclear Materials, 343: 115.

Mudali, U.K., P. Shankar, S. Ningshen, R.K. Dayal, H.S. Khatak and B. Raj, 2002. Corrosion Sci., 44: 2183.

Salvago, G., L. Magagnin and M. Bestteti, 2002. Unified Approach to Localized and General Corrosion Stainless Steels. P. Electrochemical Acta, 47: 1787.

Towie, H.J., S.R. Krutz Bauer and W. Schaarwachter, 1981. Int. Cong. Met. Corr. 8th, pp: 92.