IOP Conf. Series: Materials Science and Engineering **175** (2017) 012048 doi:10.1088/1757-899X/175/1/012048

Plastic deformation effect of the corrosion resistance in case of austenitic stainless steel

F Haraszti and T Kovacs

Obuda University, Banki Donat Faculty of Mechanical and Safety Engineering – Material Science Department – 1081 Budapest – Hungary

E-mail: kovacs.tunde@bgk.uni-obuda.hu

Abstract. The corrosion forms are different in case of the austenitic steel than in case of carbon steels. Corrosion is very dangerous process, because that corrosion form is the intergranular corrosion. The austenitic stainless steel shows high corrosion resistance level. It knows that plastic deformation and the heat treating decrease it's resistance. The corrosion form in case of this steel is very special and the corrosion tests are difficult. We tested the selected steel about its corrosion behaviour after high rate deformation. We wanted to find a relationship between the corrosion resistance decreasing and the rate of the plastic deformation. We wanted to show this behaviour from mechanical and electrical changing.

1. Introduction

It knows that the most important corrosion forms in case of austenitic steels are the intergranular and the stress corrosion. The well-known susceptibility of austenitic stainless steels to intergranular corrosion after heat-treatment in the temperature range of 500°–800°C (sensitization) has long been attributed to depletion of Cr from regions of the alloy matrix adjacent to grain boundaries in which $Cr_{23}C_6$ had precipitated. Those regions of the steel in which the local Cr composition falls below about 12% have a diminished ability to form a passive film and hence corrode preferentially [1].

During the fabrication and welding technology on base of the microstructure changing become sensitised [2]. The precipitation showed in Fig. 1. The plastic deformation modifies the grain size and the welding technology causes heat input in practise.

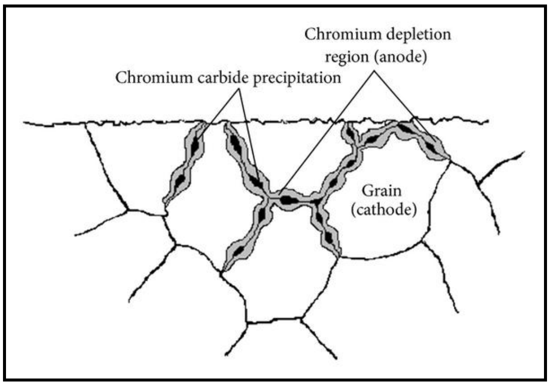

Figure 1. Schematic representation of the carbide precipitation at grain boundaries in austenitic stainless steel. *Source: http://www.hindawi.com/journals/ijelc/2013/970835/fig10/*

The measuring of the sensitization effect is very difficult experiment, usually use analytical or electron microscopy. In this way we need a test sample from the experimented part. We wanted to find a non-destructive experimental method to detect the sensitization. It known that the conduction of the metals depends on the microstructure and the quantity of precipitations of the material. Base of the experiments is that during the corrosion process the diameter of the sample and the conduction decrease. The relationship between the diameter and the conduction shows in (1) equation, where **R** is the conduction, **A** cross section area, **l** length and **ρ** resistivity [3-4].

$$R = \rho \frac{l}{A} [\Omega] \tag{1}$$

2. Materials and Experimental Procedures

2.1. Used materials

In case of our tests we used austenitic stainless steel (X15CrNiSi25-21, EN 1.4841, AISI 316) the chemical composition is given in Table 1. Number 3 and 4 sample were heat treated at 500°C duration range 1 hour in oven and after air cooling.

Table 1. Chemical composition of the used steel (at.%)

C%	Cr%	Ni%	Mn%	N%	Si
max. 0,20	24-26	19-22	max. 2,00	max. 0,11	1,50-2,50

2.2. Plastic deformation process

It is a cold metalworking process used to reduce the cross-section of a wire by pulling the wire through a dingle drawing die shows Fig.2. The cross-section reducing was 50%. By the way of this cold working process we wanted to increase the strength of the austenitic steel. The used austenitic steel recrystallization temperature is over than 550°C [5-6]. The cold working caused the increasing of the steel strength (R_m=1800 MPa) but on the used heat treating temperature the ultimate strength didn't decrease.

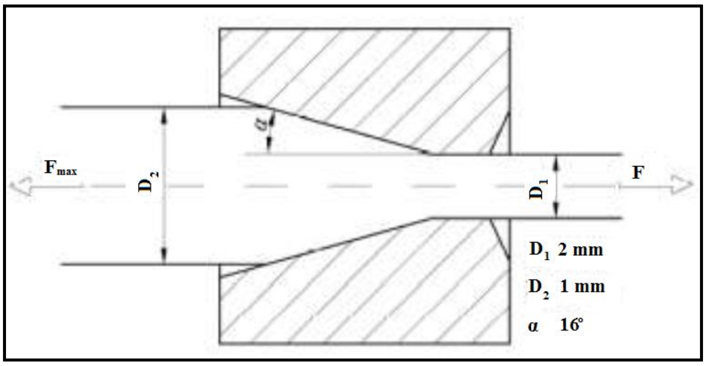

Figure 2. Metal working process

2.3. Corrosion tests

We used the Huey Test (ASTM A262) [7], used corrosive material was concentrated HNO_3 (Nitric acid) on 95°C, during 48 hours. By the way this test we can generate intergranular corrosion in the austenitic steel. The Fig.3. shows the sample number 3 surface SEM picture . On the surface of the sample we detected some cracks, assumable the cracks realized by the corrosion effect.

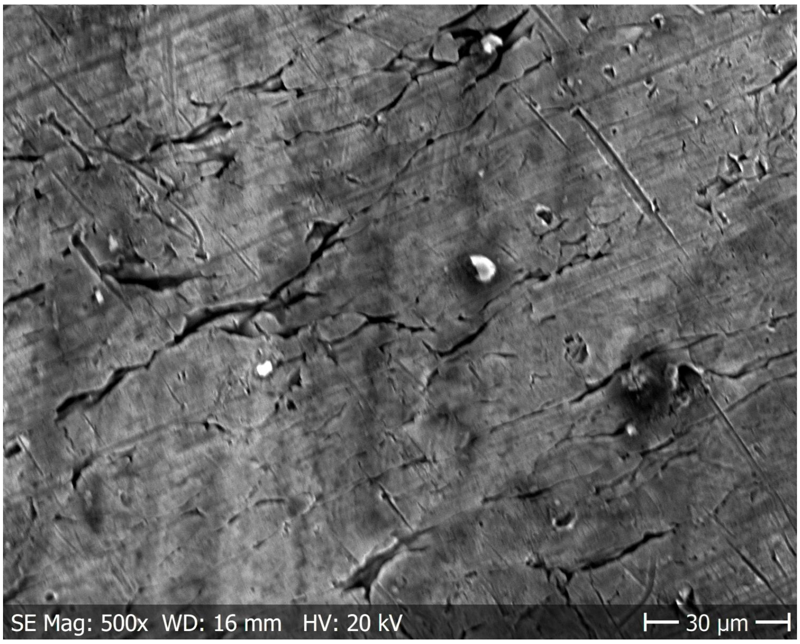

Figure 3. Surface of the number 3 sample (cold worked and heat treated)

3. Results and Discussion

Resistance testing
We tested the resistance range by the way of Wheatstone bridge.

Table 4. Resistance range in case of different treated samples

Number of sample	Samples	resistance (Ω) before corrosion test	resistance (Ω) after corrosion test
1	original sample without heat treating	0,1	0,3
2	Shaped (reducing 50%) sample without heat treating	0,3	0,6
3	Shaped (reducing 50%) sample heat treated in 500 °C	0,3	0,6
4	original sample heat treated in 500 °C	0,1	0,001

4. Conclusion

The experimental results give new information about the corrosion resistance range of the used austenitic steel.

I. After the Huey Test the resistance range changed in case of all samples.
II. In case of the number 1 sample the range of the resistance improved principally.

IOP Conf. Series: Materials Science and Engineering **175** (2017) 012048 doi:10.1088/1757-899X/175/1/012048

III. The cross section reduced samples (number 2 and 3) showed the same result about the measured resistance after the corrosion test. The resistance was the same, two times higher than before the corrosion test.
IV. In case of the sample number 4 the resistance decreased. This sample was heat treated in 500 °C without metal working.
V. We can conclude on base of our result that the used heat treating temperature (500 °C) in case of the AISI 316 austenitic steel samples doesn't caused relevant impact about the corrosion resistance when we accept the resistance range like the corrosion resistance representative.
VI. Our results are important about the corrosion resistance determination but we need more tests and result to understand this material process and base on the test parameters we can predict the corrosion behaviours. Also we need to validate our resistance tests results by the way of microstructure tests.
VII. The resistance test can be useful about the corrosion behaviour understanding because it is non-destructive test.

References
[1] C.S. Tedmon et all.: Intergranular corrosion of Austenitic stainless steel, Journal of the Electrochemical Society, 1971. Vol.118 Issue 2. 192-202
[2] M. Dománkova, E Kocsisová, I. Slatkovský, P. Pinke; The Microstructure Evolution and Its Effect on Corrosion Properties of 18Cr-12Ni-2,5Mo Steel Annealed at 500-900°C, Acta Polytechnica Hungarica, Vol.11, No.3, 2014. 125-137.
[3] F. Haraszti: The bases of corrosion's investigation EME kiadó, Kolozsvár, 2016, 185-188.
[4] F. Haraszti: Corrosion investigation of steel smaples EME kiadó, Kolozsvár, 2016, 189-192.
[5] T. Kovács-Coskun; B. Völgyi; I. Sikari-Nágl;Galvanic corrosion behavirour testing in case of aluminum and steel couple EME kiadó, Kolozsvár, 2013, 201-204.
[6] Reti T, Kovacs T: A phenomenological method for the prediction of damage accumulation processes under varying external conditions In: Materials Science Forum, Vol. 414-415: 2003, 317-322.
[7] ASTM Standard Practice in A 262 for Detecting Susceptibility to Intergranular Corrosion in Austenitic Stainless Steels