CORROSION BEHAVIOUR OF LOCALLY PRODUCED

Y. F. Barakat, S. E. Khalil, M.A. El-Zomor and M. H. Ahmed
Tabbin Institute for Metallurgical Studs

Abstract

The electrochemical behaviour of 304 stainless steel (18Cr-8Ni) commercially produced in Delta steel Mill has been studied. The production process is adapted with a suitable technique for the Egyptian conditions. It has been found that the steel quenched from 1050°C into water has good corrosion resistance properties, whereas tempering at 650°C for a time ranging from 2 hr to 5 hr; led to some deterioration. This is explained by the precipitation of chromium carbide "Cr_{23} C_6" along the grain boundaries. The anodic polarization curves were obtained using a potentioscan POS 73.
The examination were carried out in 10% sulphuric acid at 20°C and 70°C. Besides, the metallographic examination was also carried out before and after polarization. The results obtained after tempering were discussed on the basis of precipitation of chromium carbides along the grain boundaries.

Introduction

The (18-8) stainless steel which is equivalent to steel 304 according to the ASTM specifications was locally produced in Delta Steel Company. It was melted in electric arc furnace of 3 ton capacity. The produced steel ingots were then rolled into rods of 22 and 32 mm diameter in the rolling shop for reinforcing steel bars of Delta Steel Co.

In order to evaluate the corrosion behaviour of this steel at different temperatures, the passivity was studied by the potentiostatic polarization curves, using potentioscan which maintains the investigated metal at constant potential with respect to reference electrode in a 10% sulphuric acid medium. The polarization curves of stainless steel 18/8 were measured for the as rolled, water quenched from 1050°C and water quenched from 1050°C followed by tempering at 650°C for different time intervals ranging from 2 to 5 hours.

Experimental Technique and Procedures

The 18/8 steel melted in electric arc furnace and rolled to bars of 22 mm diameter were machined to 20 mm diameter and cut into small cylindrical shape of 10 mm length. The chemical composition of the produced steel was determined by atomic absorption method using Perkin Elmers equipment. The result of the analysis is shown below :

	C	Cr	Ni	Mn	Si	S	P	Fe
w%	0.12	17.6	8.0	1.15	0.5	0.025	0.035	balance

The specimens were then heat-treated by holding at 1050°C for 15 minutes in a muffle furnace and quenched in (0.5 M NaCl) brine solution. After quenching, a tempering process was carried out at 650°C for different time intervals up to 5 hours.

A copper wire was soldered to each specimen and covered together with the specimen with silicon rubber to protect them from the surrounding medium except one face of the sample representing the acting working electrode.

The specimens were ground using different grads of silicon carbide papers, then polished with fine diamond paste. The scratch-free specimens were washed by acetone, alcohol and dried.

The polarization measurements were carried out in a glass cell containing 10% sulphuric acid. A Wenking Potentioscan type POS 73 used with a scanning rate of 10 mv/sec.

The cell contained the stainless steel sample as the working electrode in addition to a platinum auxiliary electrode and a 'calomel' reference electrode. The temperature was kept constant at 20°C or 70°C using thermostat type MLW-U15. Metallographic examination was carried out using light microscope NEOPHOT-21

Results and Discussion :

Stainless steels and chromium containing steels of more than 12%Cr are characterized by their excellent corrosion resistance which is explained by the phenomenon of passivity caused by the formation of a thin chromium oxide film on the surface.

In this work, the polarization properties of the locally produced stainless steel were measured for samples in the three different conditions, the as rolled, Figure (1), the water quenched from 1050°C, figure (2),and the quenched and tempered at 650°C for different times, figures (3) and (4).

The obtained results show that the steel has good corrosion resistance and its passivity range is comparable with that of the imported. 304 type [2,3]. It is seen that the steel in the as rolled and the quenched conditions have better corrosion resistance, i.e., the maximum active current density is lower.

It is well known that on heating 18/8 stainless steel above 450°C chromium carbides will precipitate on the grain boundaries. As a result, chromium concentration may fall locally below the minimum value (12%) necessary for good corrosion resistance.

The dangerous temperature range, in which chromium carbide precipitation and chromium impoverishment occur on the austenite grain boundaries, lies between approximately 500°C and 700°C due to the difference in the diffusion speed of chromium and carbon in this range. Chromium cannot diffuse as rapidly as carbon so that, during the precipitation of chromium carbides, chromium is exclusively abstracted from narrow area adjacent to the grain boundaries [1-4]. Since the passivation of steel declines with the decrease of chromium content, the electrolyte may be able to activate the low chromium zone along the grain boundaries but not the unaffected surface of the grains which remains passive. In this respect, more active current was observed for the steel subjected to tempering at 650°C for 5 hours,

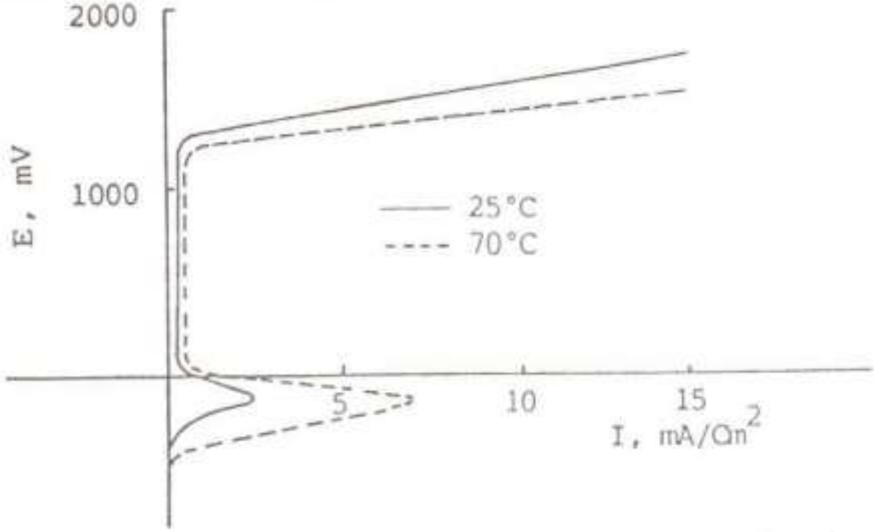


Fig (1) Polarization curve "anodic behaviour" of as-rolled stainless steel 18-8; in 10% H_2SO_4.

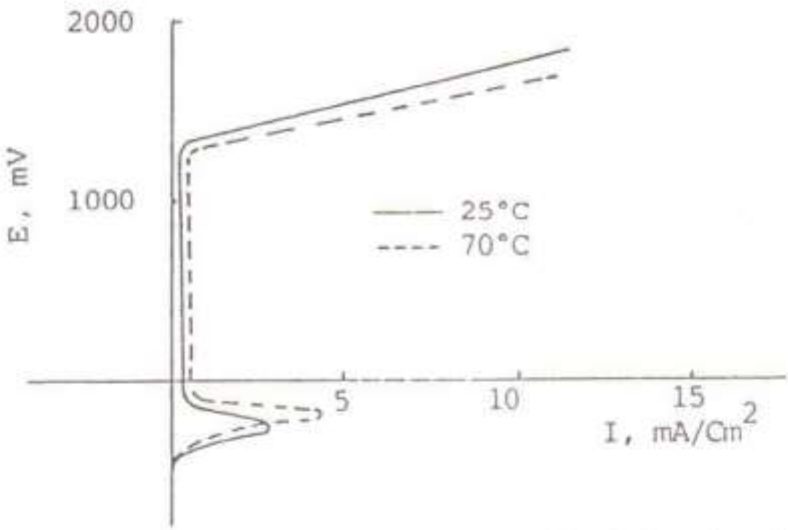


Fig (2) Polarization curve "anodic behaviour" of stainless steel 18-8, water quenched from 1050°c; in 10% H_2SO_4.

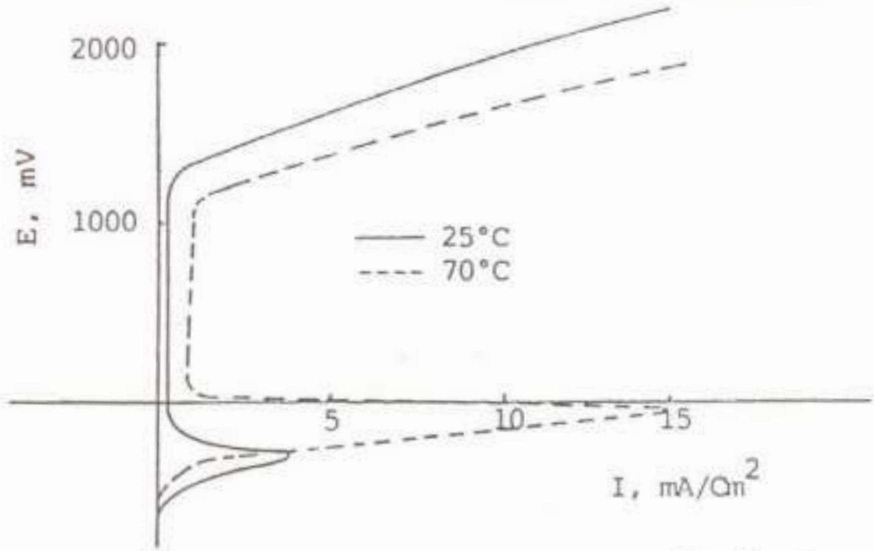


Fig (3) polarization curve "anodic behaviour" of stainless steel 18-8; water quenched from 1050°C and tempered at 650°C for 2h; in 10% H_2SO_4.

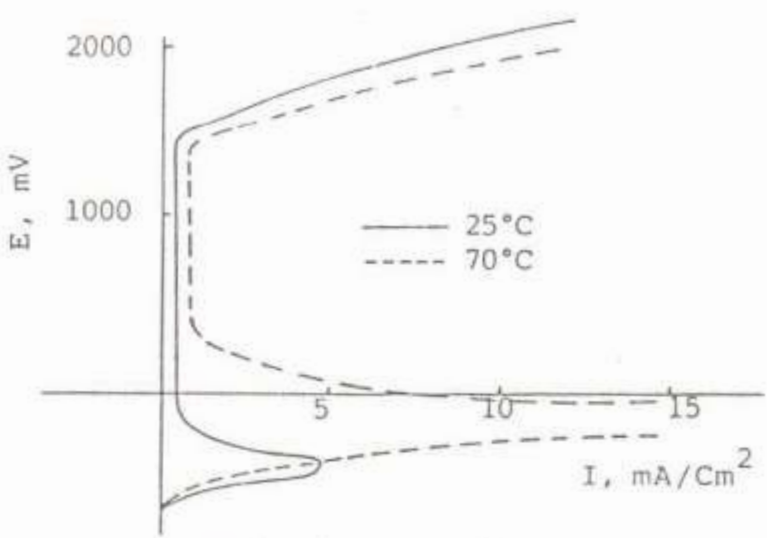
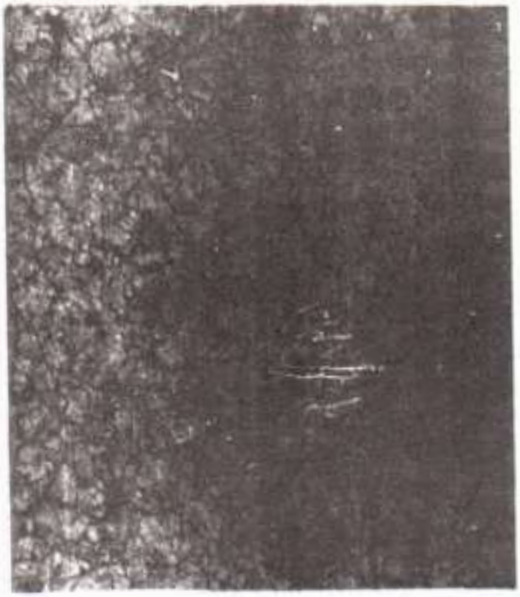


Fig (4) Polarization curve "anodic behaviour of stainless steel 18-8, water quenched from 1050°C and tempered at 650°C for 5h; in 10% H_2SO_4.



Micrograph (1) x 250

Stainless Steel 18/8 austenitised at 1050 °C and water quenched , (after polarization at 70 °C .)

Micrograph (2) x 250

Stainless Steel 18/8 quenched and tempered at 650 C for 5 h (after polarization at 70 C) figure (4), which reflected higher corrosion rate [6] as can be depicted from micrographs [1] and [2]. Apart from the active current, all the passive region is quite closed in all samples with different preparation routes [7,8]. The final observed part of the polarization curves, is the transpassive region which is characterized by another active current. The corresponding transpassive potential is not so different in all cases of specimens.

Conclusion

The 18/8 stainless steel which was produced in Delta Steel Co has good corrosion resistance. The critical points of passivation, the transpassive and active current are dependent on the heat treatment applied, i.e., the tempering temperature and time, as well as on the temperature of the polarization process. In the present study, the corrosion resistance of the locally produced steel decreased in the quenched and tempered at 650°C condition due to precipitation of Cr_{23} C_6 and the consequent depletion of the grain boundary zones from chromium similar to the effect reported for the AISI type 304 stainless steel in the cold worked/tempered condition [4].

References

1) Donald Peckenr and I. M. Bernsten, "Hand Book of Stainless Steels", Mc Graw Hill book Co. 1977.
2) John Sedriks, A., "Corrosion of Stainlees Steels", John Willy & Sons - New York, 1979.
3) Mars G. Fontana and Norbert D. Green, "Corrosion Engineering" McGraw Hill Book Co. 1989.
4) Paravthavathani N., "Influence of Prior Deformation on the sensitization of AISI type 304 Stainless Steel" Brit. Corr. Journal, vol. 26, No. 1, pp 67-76, 1991.
5) Vasudevan S., Raja V. S., Seshan S. and Chattopadhayay K. "Study of Influence of Mn Additions on Electrochemical Corrosion Behaviour of Austenitic Spheroidal Graphtic Iron." Brit. Corr. Journal, Vol. 21 No. 2, pp. 87-95, 1986.
6) Clevland J. H., Deplangue R. and Edeleanu C., "Testing of the Limits of Stable Passivity of Stainless Steel Alloys, Brit. Corr. Journal Vol. 18, No.

3, pp 120-1213, 1983.

7) Dayal R. K., Parathavarthini N. and Gnanamoorthy N., "Means of Crivice Corrosion Resistance of Stainless Steel Using a Potentiodynamic Methods Brit Corr. Jouranl, vol. 18, No. 4, pp 184-187, 1983.

8) Kruger J., "Passivity of Metals", International Materials Review, Vol. 33, No. 3, 1988.