Effect of cold rolling on the pitting corrosion of austenitic stainless steels

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INTRODUCTION

This paper deals with a not very often investigated topic on relations between cold-working and stainless steels localized corrosion resistance [1-5]. It is devoted to the study of the cold-rolling effects on the pitting corrosion behavior of various austenitic grades in chloride containing aqueous electrolytes. It focus particularly on the analysis of metastable pitting transients observed at Open Circuit Potential using an experimental protocol including two identical working electrodes connected through a zero-impedance.

EXPERIMENTAL WORKS

As received the used specimens were heat-treated at 1100°C for 30 s and cold-rolled at 10%, 20%, 30% up to a final reduction pass of 70%. Four austenitic grades with various stability regarding the induced martensite and various stacking fault energies are considered. Samples are polished with diamond paste to 3µm then current-potential fluctuations measurements were performed at OCP in NaCl 0.1M + $FeCl_3$ 2.10^{-4}M containing aqueous solution during 24h from the immersion time.

RESULTS

As expected, a detrimental effect on corrosion behavior induced by cold rolling has been observed. Surprisingly, a nonlinear effect as a function of cold-rolling rate is noted. On the one hand, the results show a maximum of the metastable pits initiation frequency at 20% of cold-rolling rate whatever the used grade (Figure 1). On the other hand, the ratio of increase of this frequency at 20% of cold-rolling rate compared to annealed state is dependent on the hardening properties of the metal studied by tensile tests. Elsewhere, it is noted that both weak stacking fault energy and grade's instability increase this ratio. Finally, It's expected a marked influence of the dislocations structures in agreement with the mecanochemical theory discussed by Gutman [6].

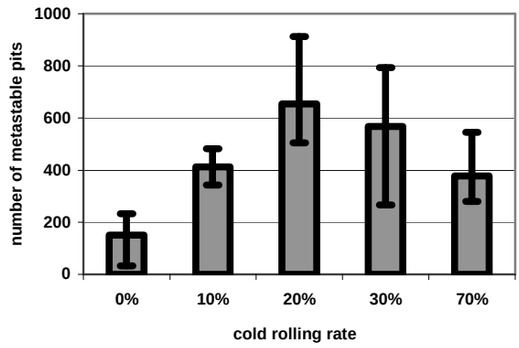

Figure 1 : Pits cumulated number for 24h as a function of cold rolling rate for AISI 304 in 0.1M NaCl+2.10^{-4}M $FeCl_3$.

Thus, it's assumed that the nonlinear nature of this behavior is attributed to a maximum of dislocations pile-ups for intermediate deformations. These are all the more large and stable as the stacking faults energy is weak and the austenite instability allows a large hardening. Observations by TEM for the 70% cold-rolling rate show the dislocations cells formation connected with the destruction of dislocations pile-ups. At the same time, there is a frequency drop all the more marked as the recovery is completed for the grades whose austenite phase is stable.

CONCLUDING REMARKS

As expected, a detrimental effect on corrosion behavior induced by cold-rolling has been confirmed on various austenitic stainless steels. We note a maximum of metasable pits initiation frequency at 20% of cold-rolling rate which controverts the hypothesis that strain induced martensite is the principal factor to explain this kind of sensibilisation. this nonlinear effect as a function of cold-rolling rate is assumed to be due to dislocations pile-ups in agreement with the theory discussed by Gutman. We have supported this idea by the study of various austenitic grades to link corrosion and hardening properties via the martensite content and the stacking fault energy.

REFERENCES

[1] G. Salvago, G. Fumagalli, D. Sinigaglia, *Corrosion Science*, **23**, 515 (1983).
[2] R. Stefec and F. Franz, *Corrosion Science*, **18**, 161 (1978).
[3] B. Mazza at.al, *Corrosion Science*, **19**, 907 (1979).
[4] U. Kamachi Mudali at.al, *Corrosion Science*, **44**, 2183 (2002).
[5] A. Barbucci at.al, Journal of the electrochemical Society, **149**, B534 (2002).
[6] E.M. Gutman, *Mechanochemistry of solid surfaces*, Worl Scientific Publ. (1994).