Modeling Crevice Corrosion of stainless steel

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INTRODUCTION

The present work concerns the study of the effect of industrial surface finishes on the durability of a stainless steels in situation of crevice corrosion. Two surface finishes of AISI 430 ferritic stainless steel were used: 2B (cold worked sheets annealed in an oxidizing atmosphere, then pickled in an acidic bath), and BA (bright annealed in a protective atmosphere of hydrogen and nitrogen). The objective is to investigate the stationary propagation process of a crevice in order to distinguish the respective contributions of external surfaces to the crevice (oxygen reduction, electronic transfer through passive film) and the internal ones (anodic dissolution, internal cathodic reactions, repassivation). A descriptive mechanism, based on the contribution of the anodic and internal cathodic reactions taking into account the role of the active/passive transition, is suggested.

EXPERIMENTAL WORKS

A crevice corrosion experiments were carried out using an original electrochemical noise measurement technique[1,2] at the open circuit potential. The specimens were disks (diameter: 30 mm) cut from industrial stainless steel 2B and BA. The current and potential measurements were performed in air saturated NaCl aqueous electrolytes (0.5M) at 23°C or 50°C. The bulk solution pH was close to neutrality (pH= 6.6).

RESULTS

Three stages were evidenced: crevice corrosion incubation, initiation, , characterized by a potential drop and an increase in corrosion current, and during the last stage "propagation", two periods have been observed: (1) transient behavior period, which was related to oxygen cathodic reaction kinetic and double layer properties, and (2) the stationary one, where potential and current reach asymptotic values.

Furthermore, the results show a strong resistance of BA compared to 2B, a ratio of five between the two values of the crevice current was noted, cf. Figure 1. Moreover, the measured working electrode potential was observed to be the same for the two surface finishes.

Beside this, several experiments have been carried out to evaluate counter electrode effect. It is concluded that the asymptotic crevice current is controlled by the crevice area, and the external cathodic reaction have only a secondary effect. Hence, the crevice potential is postulated to be controlled principally by the internal

cathodic reaction of hydrogen evolution. This hypothesis was confirmed in literature by acoustic emission technique where the hydrogen bubbling within crevice is found to be the emissive source during the propagation stage[3,4]. Consequently, the local pH of the transition passive/active (depassivation pH) becomes the controlling parameter governing the propagation processes of crevice. In fact, the pHd of 2B passive film is greater than the BA one (this is related to the chrome content of the passive film), so the 2B active area is the greatest one.

Finally, the crevice chemistry is modeled using the finites elements method, where the objective is to asses the above major observations. The results are discussed in this experimental framework and a number of proposals are advanced.

Figure 1 : Potential and current evolution, of 2B and BA 430 SS surface treatments, during the propagation stage of
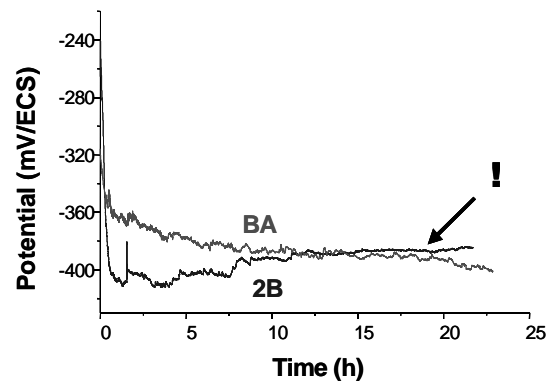
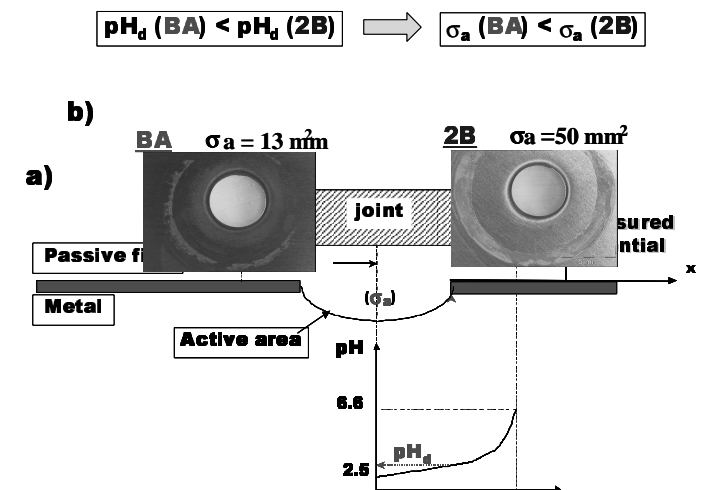crevice corrosion, in 0.5 M NaCl pH=6.6 at 50°C.

Figure 2 : Crevice corrosion propagation mechanism: a) the local pH of the transition passive/active (depassivation pH) is the controlling parameter governing the propagation processes of crevice; b) the microscopic observations show that the 2B active area is greater than the BA one.

References

1. J.L.Dawson, D.A.Eden, R.N.Carr, Patent number PCT/GB92/00527, 23/02/92, Publication number WO 92/16825.
2. G.Berthomé, Thèse., INP Grenoble (2001).
3. Y.P.Kim, M.Fregonese, H.Mazille, D.Féron, G.Santarini, NDT&E International 36 (2003) 553-562
4. Y.P.Kim, Phd, INSA de Lyon (2003)