

Corrosion behaviour of low-Si alloyed steels in neutral aqueous solutions at 90°C

S. Giordana, E.M.M Sutter, I. Mabile, C. Fiaud
 LGPPTS / UPRES 287
 ENSCP, 11, Rue Pierre et Marie Curie, 75231 Paris
 Cedex 05, France.

Unalloyed steel and low-alloyed steel generally undergo predictable uniform corrosion and are therefore widely used as engineering materials and are potential candidate materials for nuclear waste disposal containers. Binary Fe-Si alloys with a Si atomic content of 14 to 25% are very resistant against general corrosion in acids due to the formation of a passive film of SiO_2 . Unfortunately these alloys are not weldable. For low Si alloyed steels, the passive behaviour has been reported to be controlled by the formation of a Fe oxide layer. In this case, silicon as an alloying constituent below 7.6 at.% deteriorates the passivation behaviour by disturbing the passivation mechanism.

In this work, electrochemical investigations on low-Si alloyed steels with Si content ranging from 0 to 3.2 wt% (6.2 at.%) were carried out in a 0.1 M NaCl borate-buffered solution (pH=8.4) at room temperature and at 90°C, with and without oxygen in the solution. The behaviour of the alloy is compared to the behaviour of an unalloyed steel (C38). Silicon as an alloying element is shown to hinder the ability of the alloy to passivation. (figure 1). Moreover, in the Fe-Si alloy, the breakdown of the passive film occurs at a potential more negative than for the unalloyed steel. These results are in good agreement with the conclusion of ref [1]. Similar behaviour is observed at the room temperature and at 90°C.

After longer immersion times (up to 14 days), the tendency is inverted [2]. Figure 2 shows the mass loss of an unalloyed steel and a Fe-Si alloy with 3.2 wt% Si, as a function of the immersion time, in air saturated 0.1M NaCl borate solutions at 90°C. For the unalloyed steel, the rate of corrosion is constant within 14 days ($0.4 \text{ mg cm}^{-1} \text{ day}^{-1}$). For the Fe-Si alloy, a decrease of the corrosion rate is observed after 3 days of immersion, due to the formation of a protective layer.

The oxide layers formed at the surface of the unalloyed and of the alloy containing 3.2 wt% Si were analysed using scanning electron microscopy, energy dispersive X-ray spectrometry and infrared spectroscopy. In the experimental conditions of figure 2, the corrosion products at the Fe-Si alloy are a mixture of magnetite (Fe_3O_4) and maghemite ($\gamma\text{-Fe}_2\text{O}_3$), whereas those at the unalloyed steel contain also $\beta\text{-FeO(OH)}_{1-x}\text{Cl}_x$ (akaganeite) which has to be correlated with the low resistance of the layer.

From these results the influence of silicon in low alloyed steels on the mechanism of passivation after long time immersion is discussed.

REFERENCES

1. U. Wolff, F. Schneider, K. Mummert and L. Schultz, *Corrosion*, **56**, 1195 (2000).
2. S. Giordana, C. Fiaud, *Electrochim.Acta*, **47**, 1683 (2002).

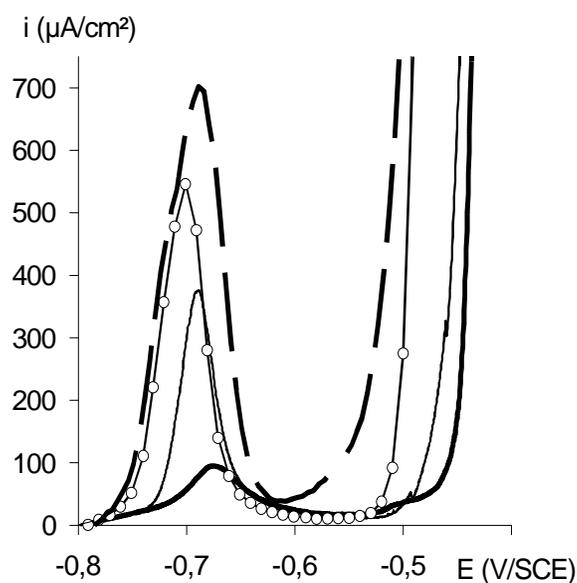


Fig 1 : Anodic $i = f(E)$ curves at 90°C in N_2 saturated 0.1M NaCl borate solution for different alloys: C38 — 0 wt.% Si —
 1.4 % Si ○—○—○
 3.2.% Si — —

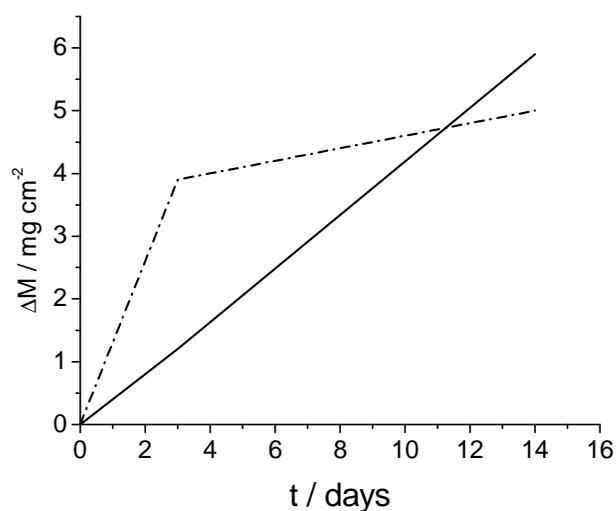


Fig.2 : Mass losses at 90°C in air-saturated 0.1M NaCl borate solution
 C38 — 3.2 wt.% Si - - - - -