

## Study of pickling and over-pickling mechanisms of silicon high alloyed steel grade by Electrochemical Impedance Spectroscopy

### Spectroscopy

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In the hot strip mill, a main part of the flat carbon steel fabrication process, steel surface is in contact with humid air at high temperatures. Under these conditions, an oxide layer called scale is formed. This layer is dissolved in pickling bath (hydrochloric acid solution) to recover a metallic and smooth surface, necessary for the following process steps and surface quality requirements.

The presence of some alloying elements (as Mn, Si, Al...) at high concentrations in steel modifies scale composition and chemistry after oxidation in the hot strip mill. As a direct consequence, scale dissolution (pickling) and metal corrosion (over-pickling) are also affected. An understanding of pickling and over-pickling mechanisms is necessary for a better management of the pickling process and the steel surface quality at pickling exit.

In this study we focused on the effect of silicon on pickling and over-pickling mechanisms. Scale is characterised by optical and electronic microscopy and by analytical methods (thickness, phases, chemical composition...). The scale dissolution was studied as a function of time and scale composition using electrochemical measurements (corrosion potential, polarisation curves, impedance diagrams...). The present work is mainly focused on the impedance analysis.

The results revealed a mono-phase scale for non alloyed steels and a multi-phase scale for silicon alloyed steels with a prevalence of wüstite (FeO) for the two grades. The electrochemical measurements showed that scale is conductive and its dissolution in acid is a combination of chemical and electrochemical reactions. The temporal evolution of the impedance diagrams and of the corrosion current of silicon alloyed steel scale during pickling were recorded.

The thin outer layer formed on the wüstite is mainly composed of Fe<sub>2</sub>O<sub>3</sub> which is difficult to dissolve. The corresponding impedance is very high and the corrosion current is low. The corrosion potential is clearly anodic, about +0.35 V/SCE, see Figure 1. During the first 400 min of immersion, the potential stays anodic but the impedance decreases with time and the corrosion current increases. After 400 min, the potential decreases sharply and becomes cathodic. This behaviour is explained by the

fact that the electrolyte reaches the metal. The cathodic potential value obtained after 700 min of immersion corresponds to the corrosion potential of the bare metal in this electrolyte.

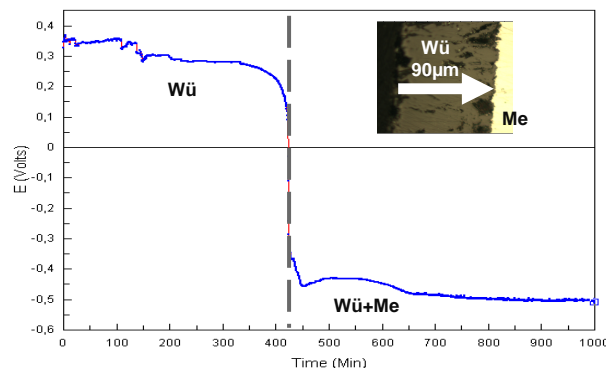


Figure 1: Corrosion potential versus the immersion time.

The impedance spectra were recorded during the immersion time and were analyzed by considering the system to be controlled by the potential (Figure 2). The corresponding charge transfer resistance and the double layer capacitance were determined, and their evolution analyzed to characterize the pickling process.

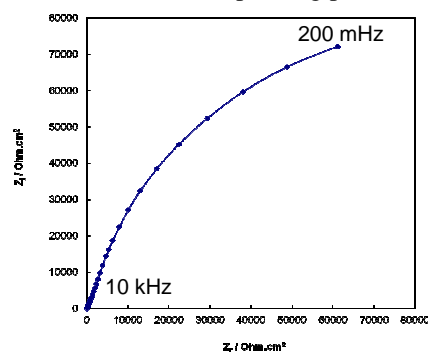


Figure 2: Example of impedance diagram measured after few minutes of immersion.