

## In-situ study of corrosion in high strength steels by AP-XPS

### THE INDUSTRIAL CHALLENGE

Traditional high strength steels (HSS) used by SSAB in waste recycling equipment are exposed to aggressive environments causing corrosion. By developing new products with different surface oxides to reduce the corrosion, the lifetime of the equipment can be significantly extended. For SSAB it is important to understand the phenomena of the passive layer of the existing and improved product during corrosion so that the composition and thickness of the surface layer can be optimized and utilized most effectively at the customer.

### WHY USING A LARGE SCALE FACILITY

The high brightness of the synchrotron allows to perform ambient pressure XPS (APXPS) measurements even if the photoelectron signal is attenuated by liquid electrolyte layer and scattering on residual gas molecules. The APXPS setup with electrochemical cell enables direct study of the chemical composition of the surface in presence of thin liquid electrolyte layer directly after electrochemical reaction.

### HOW THE WORK WAS DONE

The experiment was performed at HIPPIE beamline (MAX IV, Lund). Samples were cut from HX450 and HXHiAce plates and polished to achieve surface roughness of 3  $\mu\text{m}$  to facilitate homogeneous wetting properties.

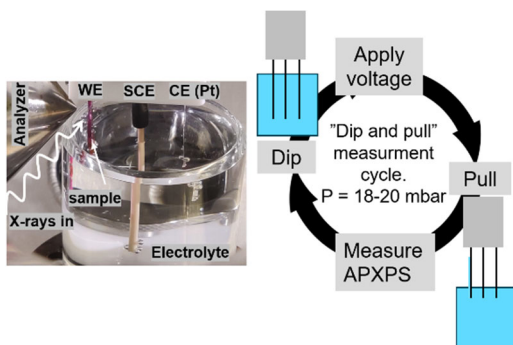
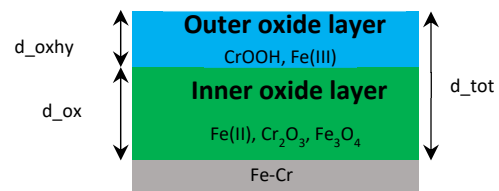


Figure. Left: The manipulator in the dipped position, Right: the "dip and pull" measurement cycle.

The sample holder has slots for the sample, which also acts as working electrode, as well as for the SCE reference- and Pt counter electrode. It was placed on the manipulator in the vacuum chamber kept at 18-20 mbar. To run the electrochemical reaction electrodes were dipped in the beaker with degassed electrolyte and the potential was applied by a potentiostat connected to manipulator. The  $\text{CH}_3\text{COOH}$  (pH 4.5) and 0.01M NaCl electrolytes were used for tests. After fixed time electrodes were pulled from the beaker and APXPS spectra were measured through the residual thin electrolyte film, while sample was at OCP conditions.

### THE RESULTS AND EXPECTED IMPACT



The results revealed that the stability and composition of the oxide layer is different when the HSS surface is corroded by the weak acetic acid solution as compared to the salt solution. The surface oxide of the HSS in the pH 4.5 electrolyte increased in oxide thickness. At increasing corrosion currents,  $\text{Fe}_3\text{O}_4$  increases as rust appears in the HX450 whereas the  $\text{Cr}_2\text{O}_3$  and Cr hydroxide are depleted in the HXHiAce, unable to repassivate the surface. In the salt solution, both materials saw an increased thickness of the oxide layer; however, for the HXHiAce the outer oxide did not form a continuous layer and the Cr was not replenished. The results contribute to the strategic efforts of Swedish metal industry and Swerim to develop more sustainable products with longer useful lifetimes.

***"Being at MAX IV provides a great opportunity to learn and use new techniques to study corrosion behaviour on surfaces. Being able to induce corrosion and study the steel surfaces in-situ is a huge leap forward."***  
/D. Orrling, SSAB Special Steels

**SSAB** 

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