

Application of the EPR-Test to 13% chromium steel and the role of sulphide inclusions

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The manufacturer of specific electric power generators uses components made of the chromium alloyed steel X12Cr13 (Mat. No. 1.4006, 13% Cr) from various suppliers. These components are exposed to atmospheric conditions and staining is sometimes observed, in maritime climates but also on stock. It was the aim of this work to identify the cause of this behaviour and to elaborate a corrosion test for quality assessment of these components based on the electrochemical potentiokinetic reactivation test (EPR-, Cihal-Test).

Investigations were carried out using samples from two different suppliers (SSA and SSB). The chemical composition of both materials was analyzed by sparc emission spectroscopy and was found in the specified range. In order to assess the susceptibility to chloride induced corrosion by potentiodynamic measurements, samples of the materials were finely ground and passivated in nitric acid. A cylinder made of plexiglass was glued to the surface, serving as electrochemical cell by inserting a reference and a counter electrode. Sodium chloride solution (100 mg/L chloride) was the electrolyte. Determination of pitting potentials was successful only with SSA. SSB did not exhibit a well pronounced passive range. Metallographic investigation involved etching the polished surfaces and light microscopy. For SSB, a ferritic structure with carbide precipitates along the grain boundaries was found, i.e. the material was in a sensitized state. Moreover, relatively large sulphide inclusions were identified SSA did not exhibit such structures.

Electrochemical assessment of sensitization was done by the using the double loop method. The procedure is based on previous work [1]. The electrolyte was 0.5 M H₂SO₄ and the potentiodynamic scan was from -500 mV_{SCE} up to +500 mV_{SCE} and return at 1,67 mV/s. To set up the test, a plexiglass cylinder with an o-ring was pressed onto the ground surface and the electrodes were inserted. The ratio of the peak currents during the anodic and cathodic scan, respectively, were evaluated as relative electrochemical degree of sensitization ($S_E = I_{p,c}/I_{p,a}$). Results of the as delivered samples and of heat treated samples allowed to verify this testing procedure for SSB. In contrast, SSA exhibited current peaks during the cathodic cycle, even after solution annealing. The results of further investigation of this phenomenon by scanning electron microscopy, metallography and chemical treatment of the surface indicate that sulphide ions, generated by the dissolution of the inclusions during the EPR-test, may act as activator. They reactivate the surface, at least locally, during the cathodic cycle, independent of the degree of sensitization. Consequently, interpretation of results from EPR-test of martensitic stainless steel with such a rather low chromium content in terms of sensitization requires additional information on the materials structure.

[1] N. Alonso-Falleiros, M. Magri, and I.G.S. Falleiros, Corrosion 55(1999), p. 769.