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Corrosion of stainless steel grades in H_2O/KOH 50% at 120 °C: AISI304 austenitic and 2205 duplex

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We report on the corrosion of austenitic (AISI304) and duplex (2205) stainless steels in H_2O/KOH 50% at 120 °C. The research is based on a combination of electrochemical, structural and compositional analyses, aimed at assessing the surface modifications resulting from anodic attack and their impact on corrosion resistance. Linear sweep voltammetry and electrochemical impedance spectrometry measurements were carried out in an air-tight high-temperature cell. In-plane and cross-sectional SEM micrography, X-ray diffractometry and EDX profiling were used to characterise samples attacked under electrochemically controlled conditions. Electrochemical results have shown that AISI304 exhibits a complex passivating behaviour, while the anodic electrokinetics of the duplex is characterised by mixed kinetic control. AISI304 was found to fail by intergranular corrosion and to be covered: in passive conditions by acicular compounds and in transpassive conditions by a compact layer of corrosion products. Duplex samples, instead, exhibit an uniform form of corrosion morphology and bear a compact layer of corrosion products both in passive and in transpassive conditions.

1 Introduction

The understanding of ferrous alloy corrosion in hot concentrated alkaline aqueous solutions is gaining momentum owing to the growth of industries exhibiting process conditions giving rise to this type of attack. In particular, devices suffering severe degradation deriving from this type of environment are: nuclear systems where the temperatures are high and the caustic concentrations can lead to corrosion and stress corrosion cracking (SCC) problems, pulp mills and a broad class of chemical plants. Details on the relevant devices and respective material stability problems are reported below.

Nuclear power plants convert the energy released in a nuclear fission that takes place in a nuclear reactor to generate steam which drives a turbine connected to a generator producing electricity. Steam generator tubes made of ferrous alloys operating in such caustic environments are typically prone to SCC, in particular exhibiting trans-granular (TG) SCC at the crack mouths and changing to inter-granular (IG) SCC at the crack tips.

Pulp mills are manufacturing facilities in which wood chips or other plant fibre source are converted into a thick fibre board which can be shipped to a paper mill for further processing. Pulp can be manufactured using different methods that can be mechanical, semi-chemical or fully chemical (Kraft and sulphite processes) approaches. In the chemical processes, a combination of high temperature and alkaline (Kraft) or acidic (sulphite) chemicals are employed to break the bonds of the lignin present in wood and other plant materials. Kraft pulp mill equipment, commonly made by different types of carbon steel, is exposed to sulphide-containing caustic liquors and is susceptible to corrosion and SCC due to action of these high-pH liquors especially at higher temperatures.

As far as stainless steel grades in particular are concerned, in the two above-mentioned industries, as well as in several niche applications, there has been a growing interest in the resistance to hot alkaline aqueous solutions at temperatures close to the boiling point. On these topics the technical literature available at the time of this writing it is still limited. In the following, we shall offer a brief overview of the available relevant literature.

In Ref. [1] the effect of heat treatment on corrosion and SSC of S32205 duplex stainless steel in caustic solution has been investigated. Small test coupons measuring $12 \times 10 \times 10\,mm^3$

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