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Comparison of descaling methods to study the corrosion kinetics of ferritic steels after dynamic exposure to molten carbonates

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ABSTRACT

T91 ferritic-martensitic steel was exposed to Li, Na and K molten carbonates at 650°C under dynamic conditions up to 1000 h. After testing, three descaling methods, two from the ISO8407 and one from the ISO17245 standards were applied to remove the corrosion products and determine the corrosion rates. The two ISO8407 methods were more appropriate although the procedure required several steps to fully remove the corrosion products. The ISO17245 method led to a higher mass loss affecting probably the base material. Oxides identification was performed by XRD following step by step layers removal. Li-, Na-, K-containing oxides and chromates/chromites were detected.

1. Introduction

The use of heat transfer fluids such as molten salts in Concentrated Solar Power (CSP) plants requires to find the best compatibility between these salt mixtures and the construction materials. Due to the large contact surface of the tubes and tanks materials with molten salts, corrosion product formation is a critical issue in CSP plants. The corrosion products reduce the thermal conductivity of the heat exchanging processes and transportation of these products throughout the whole molten salt circuit may occur, resulting in blocking and also causing crevice corrosion in other areas [1–3].

Low carbon and stainless steels as well as nickel based alloys are currently used as construction materials for tubes and tanks in contact with the "Solar Salt", a eutectic mixture of sodium and potassium nitrates (60:40). However, increasing the efficiency of the next-generation CSP plants is a prime objective, and other molten salts capable of operation at temperatures higher than 580°C must be developed, including a study of their compatibility with the construction materials. Previous laboratory testing with a different dynamic facility were carried out with two low-cost coated solutions along with uncoated T91 ferritic-martensitic steel exposing them to molten carbonates at 650°C for comparison purposes [4]. This study particularly evidenced the poor corrosion resistance of T91 under dynamic conditions while demonstrating the importance of descaling the corroded specimens in order to measure the metal loss. The evaluation of new materials for CSP plants with or without coating solutions requires a sound study of their corrosion kinetics in order to be able to estimate their useful life. Since the traditional weight variation method cannot be used when extensive spallation is observed, the best alternative is to remove the corrosion products and to measure the metal loss by measuring the weight of the descaled specimens. A sound, repeatable and reliable descaling method is therefore required [5–8].

Selective chemical etching based on specific chemical dissolution of oxides and corrosion products can be applied as a good way to directly evaluate the total quantity of corroded metal. Three methods of descaling were employed and compared in a previous study after exposure of uncoated T91 to molten nitrates at 580°C under dynamic conditions with atmospheric air [9]. Gas atmosphere has a significant effect on the corrosion behaviors and oxidation-lithiation of alloys in molten carbonates. As the main objective of this study was to promote the steel oxidation to later remove the corrosion products by three different techniques, laboratory air was chosen instead of CO_2 atmosphere as used in several published studies [10,11]. Some discrepancies in the corrosion rate results were observed depending on the applied method which suggested that either one of each descaling process would seem to affect the base material or that in the other case, the descaling process was not sufficient to totally remove the corrosion products. Consequently, this work was focused on the study of T91 samples exposed to Li, Na and K

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