



Dynamic corrosion testing of metals in solar salt for concentrated solar power

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ABSTRACT

Potassium nitrate and sodium nitrate in mixing proportion of KNO_3 - $NaNO_3$ 40-60 wt% (also called solar salt) has been successfully used for over a decade as heat storage medium for concentrated solar power parabolic-trough collector plants at temperatures up to 400 °C. At temperatures of 560 °C, reached in state-of-the-art solar tower systems, corrosion of metallic components in contact with solar salt can become an issue and has caused leaks and plant shut-downs in recently built tower projects. While the corrosion rates of several materials have been determined for different temperatures in static molten salt immersion experiments, there is a lack of corrosion data for dynamic in-service conditions. In this work, a dynamic corrosion test has been conducted on 19 different material types including protective coatings, mimicking flow-rate, temperature gradient and draining of in-service operation of a receiver in a concentrated solar power tower. The measured corrosion rates are presented and compared to static corrosion tests reported in literature.

1. Introduction

The efficiency of Concentrated Solar Power (CSP) technologies increases with the operation temperature of the Heat Transfer Fluid (HTF). In the past years, molten salt has become the new industry standard HTF for power towers, replacing direct steam generation receiver types. The key advantage of this technology is that molten salt is both used as HTF and storage medium enabling cost-effective and scalable thermal storage for solar electricity production. The current CSP plants use almost exclusively the so called “solar salt”, a non-eutectic molten salt mixture with 40 wt% potassium nitrate (KNO_3) and 60 wt% of the cheaper sodium nitrate ($NaNO_3$). The melting point of solar salt is around 240 °C and its thermal stability limit is around 565 °C, although recent studies have indicated that operation up to 600 °C or even above is possible with controlled gas atmospheres, in which loss of decomposition gasses is effectively prevented [1].

Corrosion rate is the amount of corrosion loss per year in thickness.

Corrosion rates of different metals for solar salt piping, tanks and receiver tubes have been reported in literature. Fig. 1 shows a summary of the corrosion rates reported in sources [2–9]. Unless reported in the reference, the annual corrosion rate CR was computed according to equation (1), in order to compare the measured data.

$$CR \left[\frac{\mu m}{yr} \right] = \frac{87600 \cdot \Delta m}{\rho \cdot t} \quad (1)$$

where Δm is the descaled specific mass loss with respect to the initial sample surface (mg/cm^2), ρ is the alloy density (g/cm^3) and t is the testing time (h).

The data compiled in Fig. 1 refers to immersion corrosion testing of differing exposure times. For instance, the testing time in Ref. [5] was 7008 h, while in Ref. [9] only 1200 h of exposure were reached. This might be an explanation for the unexpected behavior for alloy 316 shown in Fig. 1. Another factor, which makes a comparison of the different studies difficult are salt impurities, as they are known to have a strong influence on the corrosion rate. E.g., the solar salt chloride levels

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