Announcing the Final Examination of Omar Ahmed for the degree of Master of Science

Time & Location: October 11, 2013 at 9:00 AM in OTC 304

Title: CORROSION BEHAVIOUR OF AISI 304 STAINLESS STEEL IN CONTACT WITH EUTECTIC SALT FOR CONCENTRATED SOLAR POWER PLANT APPLICATIONS

In response to the extensive energy demands on national and global levels, concentrated solar power (CSP) plants are designed to harness and convert solar energy to electricity. For such green energy application, robust, reliable and durable materials for CSP constructions are required. The corrosion resistance is among many parameters to consider in these thermal-electrical stations such as for pipes and storage tanks in CSP. In this investigation, the corrosion behavior of AISI 304 stainless steel (18 wt. % Cr, 8 wt. % Ni) with the heat transfer fluid, also known as solar salt, has been examined. The ternary eutectic salt mixture with the composition, 53 wt. % KNO3, 40 wt. % NaNO2, and 7 wt. % NaNO3, that melts at 142°C, has a potential use in CSP as a heat transfer fluid. It was prepared for this corrosion study from reagent grades of high purity nitrites and nitrates. Samples of AISI 304 stainless steel were sectioned from a sheet stock of the alloy and exposed to solar salt at 530°C in air at 1 atmospheric pressure. After test intervals of 250, 500, and 750 hours in total immersion condition, AISI 304 stainless steel samples have developed a scale of corrosion products made up of multiple oxides. X-ray diffraction and scanning electron microscopy with X-ray energy-dispersive spectroscopy were employed to examine the extent of corrosion and identify the corrosion products. Transmission electron microscopy was used to verify the corrosion products identity via electron diffraction patterns. Oxides of iron were found to be the primary corrosion products in the presence of the molten alkali nitrates-nitrite salt mixture because of the dissolution of the protective chromium oxide (Cr2O3) scale formed on AISI 304 stainless steel coupons. The corrosion scale was uniform in thickness and made up of sodium iron oxide (NaFeO2), iron oxide, hematite (Fe2O3), and chromium-iron oxide (Cr,Fe)2O3 solid solution. The latter was found near the AISI 304 stainless steel. This indicates that the scale formed, particularly on the upper layers with presence of sodium iron oxide and iron oxide, hematite, is protective, and forms an effective barrier against penetration of fused solar salt. At the alloy interface with the bulk corrosion scale, the corrosion process induced a compositional modification in the grains located at the interface, where iron rich and iron depleted grains, if compared to the nominal iron content of the alloy, were observed. The mode of attack is identified as uniform at the test temperature of 530°C, showing a parabolic behavior with a parabolic rate constant (Kp) equals to $1.08 \times 10^{-17} (m^2/sec)$. By extrapolation, annual corrosion rate is estimated to reach 0.784 mils per year. Corrosion behavior of AISI 304 stainless steel is discussed in terms of thermodynamics and reaction paths.

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Committee in Charge:
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Approved for distribution by Dr. Yongho Sohn, Committee Chair, on September 16, 2013.

The public is welcome to attend.