EVALUATION OF HIGH TEMPERATURE CORROSION IN WET AMMONIA CONTAINING ATMOSPHERES

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ABSTRACT

Ammonia is considered attractive as a CO_2-free H_2-carrier due to its high volumetric energy density, ease of liquefaction, and the availability of an existing infrastructure for transport and storage. Ammonia can be utilized as a fuel directly by combustion engines and solid oxide fuel cells (SOFC) or dehydrogenated and used as a fuel by polymer electrolyte membrane fuel cells (PEMFC). A promising technology for dehydrogenation is based on proton ceramic electrochemical reactors (PCER) that couple the dehydrogenation process with hydrogen separation and compression to achieve high energy efficiencies (>90% on higher heating value basis) [1].

Both PCER and SOFC systems operate at elevated temperatures (>600 °C) and with humidified gasses, which may pose a challenge to the integrity of alloys employed for the housing and balance-of-plant components of these systems (interconnects, heat exchangers, pumps etc.). Exposure to ammonia at elevated temperatures may result in nitridation attack, especially if the atmosphere is too reductive to form protective oxide scales [2]. Nitrogen from dissociation of ammonia may react with alloying elements such as Ti, Al, Ni and Cr to form brittle nitrides that reduce the pressure tolerance of the component and reduce the oxidation resistance of the alloy due to surface depletion of these elements. Thick nitride or oxide layers on the alloy surface may negatively impact the heat transfer across the components and thereby lower the efficiency of heat recuperators.

Ammonia synthesis is carried out in alloy-based reactors and extensive work has therefore been done to characterize the nitridation behavior in dry NH_3-H_2-N_2 gas mixtures in the temperature range of 400-1000 °C [3]. However, there is very little data available for wet NH_3-containing gas mixtures, which is important for safe operation of PCER and SOFC systems. The EU project SINGLE and the KSP project Maritime NH_3 aim to contribute to new knowledge on the nitridation and corrosion behaviour in wet NH_3-containing atmosphere, as relevant for PCER and SOFC, respectively.

A dedicated test set-up has been constructed to allow for exposure of alloy coupons to high concentration of ammonia at elevated temperature up to 900 °C and pressure up to 20 bar. Details of this set-up and preliminary results will be presented.

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