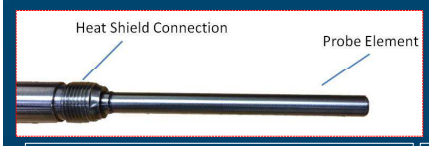
Overcoming Materials Challenges for SFR sCO_2 EC Systems

Matthew Walker

In-Situ Corrosion Monitoring System

Two activities are underway to continue the exciting developments of in-situ alloy corrosion monitoring capability in sCO_2 systems. Two large high temperature corrosion furnaces, used in FY17 for alloy corrosion experiments, are being modified to incorporate multiple in-situ electrical resistance corrosion probes. Experiments will be performed to validate measured corrosion rates versus those for witness samples of the same alloys. Prior to implementing in-situ corrosion monitors in sCO2 systems, the ability of the probes to operate within a high pressure environment needs to be evaluated. A corrosion probe will undergo testing in the new high pressure test facility at Sandia-NM to ensure that it is able to withstand this environment.

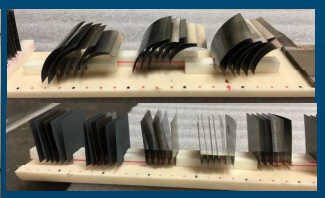


In-situ Electrical Resistance (ER) Corrosion Probe

High temperature corrosion furnaces (setup / used in FY17 corrosion tests)

High Temperature (>550°C) Bearing Coatings

Recent discussions with Industry have identified the need for gas foil bearing coating material solutions at higher temperatures (>550°C). For this work, we are collaborating with industry (Xdot and LiquidMetal Coatings) to identify and evaluate up to 6 different high temperature bearing coating materials at 2 different Temperatures for 500hr durations in high pressure CO_2. Down-selected materials would be candidates for future bearing tests by Xdot and/or Sandia.

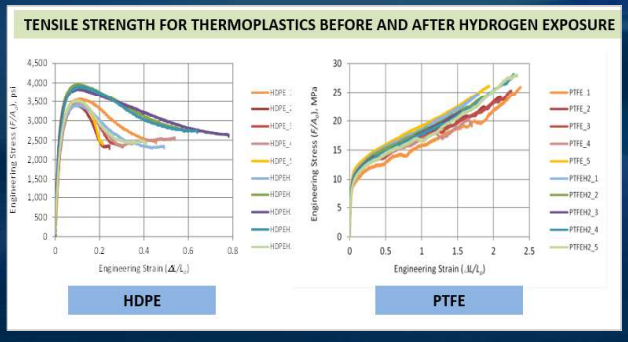


Xdot Engineering and Analysis

LIQUIDMETAL COATINGS

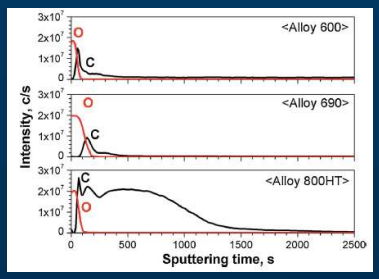
sCO2 / Polymer Interactions

Polymer bushings and O-rings are used in low temperature system equipment/components such as valves. Very little is known about the performance of these low temperature plastic materials in sCO2, but experience in our autoclave system as well as discussions with others in industry has indicated a severe need in this area. We are completing a thorough review of literature on this topic, and developing a research plan for experimental activities that are needed to resolve this risk and better inform selection of these materials for low temperature system applications. Sandia's experience from Hydrogen Codes & Standards will be leveraged on sCO2 systems (see examples below)



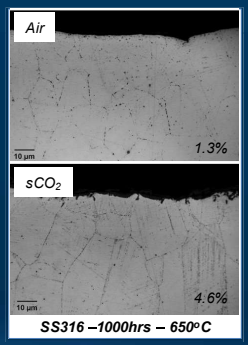
Structural Materials Consortium (Proposed)

Through extensive discussions with cross-cut collaborators (ORNL and UW-Madison), **alloy carburization has been identified as a critical materials risk for SFR EC systems**. Iron base alloys are more economical for SFR, but information is needed regarding C ingress at SFR temperatures. Mechanical properties are needed for both the base alloys and diffusion weld regions for the HX; it is critical to understand how these properties change when exposed to sCO_2 at temperature.



1000hrs - 600°C - 20 MPa sCO_2

Higher sub-surface carbon for Fe-base alloy versus for Ni-base alloys
Lee-KAIST 2015



SS316 –1000hrs – 650°C

Increased carbide precipitation in sCO_2
Olivares – CSIRO 2015

University of Wisconsin Madison	**Task 1** *Tensile performance of diffusion bonded Fe-base alloys*	(1) Perform baseline tensile testing on base metal and diffusion bonded alloys. (2) Repeat assessment of "aged" base metal and diffusion bonded samples that have been exposed to sCO2 for a thousand hours.
Sandia National Laboratories	**Task 2** *Cycle fatigue performance of diffusion bonded Fe-base alloys*	(1) Perform baseline fatigue assessment on base metal and diffusion bonded alloys. (2) Repeat assessment of "aged" base metal and diffusion bonded alloys that have been exposed to sCO2 for a thousand hours.
Oak Ridge National Laboratory	**Task 3** *Effect of Cr and Ni contents on compatibility of Fe-base alloys in sCO_2 for SFR applications*	Quantify the oxide thickness and C ingress after 1,000 h of testing in 200 bar RG CO_2 as a function of alloy Cr and Ni contents to determine if composition affects compatibility in this temperature range

U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration | Sandia National Laboratories

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia LLC, a wholly owned subsidiary of Honeywell International Inc. for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.
SAND2017-11736 C