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Environment-Induced Degradation and Crack-Growth Studies of Candidate Target Materials: Quarterly Progress Report (June 1 – August 31, 2003)

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Quarterly Progress Report
(June 1 – August 31, 2003)

Environment-Induced Degradation and Crack-Growth Studies of Candidate Target Materials
(New Project Title)

Hydrogen-Induced Embrittlement of Candidate Target Materials for Applications in Spallation-Neutron-Target Systems
(Old Project Title)

TRP Task-4

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Introduction

As indicated in the original proposal, the primary objective of this task is to evaluate the effect of hydrogen on environment-assisted cracking of candidate target materials for applications in spallation-neutron-target (SNT) systems such as accelerator production of tritium (APT) and accelerator transmutation of waste (ATW). The materials selected for evaluation and characterization are martensitic stainless steels including Alloy HT-9, Alloy EP 823 and Type 422 stainless steel. The susceptibility to stress corrosion cracking (SCC) and hydrogen embrittlement (HE) of these materials are being evaluated in aqueous environments of interest using tensile specimens under constant load and slow-strain-rate (SSR) conditions. Further, the localized corrosion behavior of these alloys is being evaluated by electrochemical polarization techniques. The extent and morphology of cracking and localized corrosion of the tested specimens are being determined by optical microscopy and scanning electron microscopy (SEM).

More recently, this experimental program has been refocused to evaluate the effect of molten LBE on the corrosion behavior of similar target materials in the presence of oxygen. Since the Materials Performance Laboratory (MPL) currently cannot accommodate this type of testing, the lead-bismuth-eutectic (LBE) loop at the Los Alamos National Laboratory (LANL) will be used to contain the stressed test specimens to evaluate the SCC, HE, and localized corrosion (pitting and crevice) behavior in the molten LBE environment. Since the magnitude of the applied load/stress during these tests cannot be monitored or controlled (as in conventional SCC/HE experiments) in the LBE environment, the test specimens will be self-loaded. Two types of specimen configurations, namely C-ring and U-bend, are being used to perform these desired experiments. The stress of principal interest in both types of specimen is the circumferential stress. SCC tests using these types of self-loaded specimens are also being performed in aqueous environments having neutral and acidic pH values at ambient and elevated temperatures.

Personnel

The current project participants are listed below.

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Accomplishments

- C-ring and U-bend specimens of Alloys HT-9 and EP-823 have been tested at 95 and 98% yield strength of these alloys at ambient temperature, 50 and 100°C in acidic solution using a Hasteloy C-276 autoclave. Testing at ambient temperature has been conducted with and without the presence of oxygen. Evaluation of the tested specimens for cracking is in progress using optical microscopy.

- A significant number of SCC tests using calibrated proof rings, and smooth and notched tensile specimens of martensitic Type 422 stainless steel, and Alloys EP-823 and HT-9 has been completed in both neutral and acidic aqueous environments under constant-load conditions at ambient and elevated temperatures. In case of Type 422 stainless, the threshold stresses for notched and smooth specimens were determined. Additional tests are ongoing using Alloys HT-9 and EP-823 to determine their threshold stresses.

- Metallographic and fractographic evaluations of all specimens tested under constant-load and slow-strain-rate conditions are in progress.

- Localized corrosion studies using an electrochemical method are ongoing to evaluate the critical potentials in both neutral and acidic environments at elevated temperatures.

- Numerous abstracts and full technical papers were sent to different conferences including MS&T (Chicago), ECS (Orlando), Global 2003 (New Orleans) for presentations and publications. All of them have been accepted.

Problems

Single potentiostats are not functioning properly. The manufacturer has been notified.

Status of Funds

Expenditures incurred during this quarter are within the target amount allocated.

Plans for the next quarter

- Perform SCC testing using self-loaded specimens at LANL in molten LBE environment.
- Perform SCC testing at elevated temperatures (up to 300^{o}C) using self-loaded specimens inside an autoclave.
- Perform SCC testing under controlled electrochemical potentials.
- Continue heat treatments of remaining heats of all three-test materials, and machine additional specimens
- Continue localized corrosion testing at 90^{o}C using cyclic polarization technique.
- Continue failure analysis by SEM and optical microscopy.
- Prepare technical/scientific papers for presentations and publications (NACE Corrosion/2004, ICONE-12 & IYC/2004).