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Effect of Silicon Content on the Corrosion Resistance and Radiation-Induced Embrittlement of Materials for Advanced Heavy Liquid Metal Nuclear Systems: Quarterly Progress Report (February – April 2005)

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Quarterly Progress Report

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Effect of Silicon Content on the Corrosion Resistance and Radiation-Induced Embrittlement of Materials for Advanced Heavy Liquid Metal Nuclear Systems

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Introduction

The purpose of this collaborative research project involving the University of Nevada Las Vegas (UNLV), Los Alamos National Laboratory (LANL) and Idaho State University (ISU) is to evaluate the effect of silicon (Si) content on the corrosion behavior and radiation-induced embrittlement of martensitic stainless steels having chemical compositions similar to that of the modified 9Cr-1Mo steel. Recent studies at LANL involving Alloy EP-823 of different Si content have demonstrated that increased Si content in this alloy may enhance the corrosion resistance in molten lead-bismuth-eutectic (LBE). Since very little data exists in the open literature on the beneficial effect of Si content on the corrosion properties, it seemed appropriate to initiate a research project to address this technical issue. This proposal is intended to study the effect of Si content not only on the corrosion resistance but also on the radiation-induced embrittlement of martensitic stainless steels. The susceptibility of these alloys with different Si content to stress corrosion cracking, general corrosion and localized corrosion will be evaluated in the molten LBE and aqueous environments of different pH values using state-of-the-art testing techniques. Testing in the aqueous media is intended to develop baseline data for comparison purpose. Radiation-induced embrittlement of these alloys will initially be studied by irradiating the test specimens with bremmstrahlung gamma radiation from 20-40 MeV electron beams at ISU. These gammas induce (γ, n) reactions in the giant dipole energy region. The principal radiation damage from these irradiations, in turn, stems from the recoiling residual nucleus (with average kinetic energy of approximately 20,000 eV) after the neutrons are emitted. The high penetrability of gammas, whose range is of order one meter in steel, ensures that the resulting damage will be uniform over the volume of the sample. The induced activity of these specimens will have very short half-lives (typically minutes) due the systematics of (slightly) proton-rich nuclei. The resulting radiation-induced hardening can subsequently be evaluated by proper experimental techniques. Later, similar studies can be performed using specimens radiated by neutrons at LANL.

Personnel

The current project participants are listed below.

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Accomplishments

- Machining of tensile and polarization specimens of T91 grade steel with different silicon content are in progress. Tensile, stress corrosion cracking and polarization experiments will be initiated soon.

- A fixture to hold Charpy V-notch specimens for impact testing will be installed in the existing instrumented impact tester in July 2005. This type of testing will enable the determination of impact energy and ductile-to-brittle transition temperature. .

- All three graduate students have been trained in high-temperature tensile testing using the MTS machine. They also got trained in using the newly-installed Instron testing equipment to perform tensile and fracture-mechanics related experiments.

- Literature review on relevant topics is ongoing.

Problem

No problems are anticipated.

Status of Funds

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

Plans for the Next Quarter

- Initiate and continue different metallurgical and corrosion testing.

- Continue literature search