National Spent Nuclear Fuel Program

Advanced Neutron Absorber

Mission
Develop a low cost, highly effective corrosion resistant material for neutron absorber components

Benefits
- Efficient, readily available, low-cost neutron absorber
- Long-term corrosion resistance
- Linear loading optimizes neutron absorption
- ASTM and ASME are met
- Experience with basalt-ceramic, the alternative to gadolinium, is also available.
- Nuclear criticality safety requirements addressed

Current Issues
Regulator acceptance of modeling system based on chemistry and natural analog systems

Project Status
Performing initial gadolinium-stainless steel alloy development

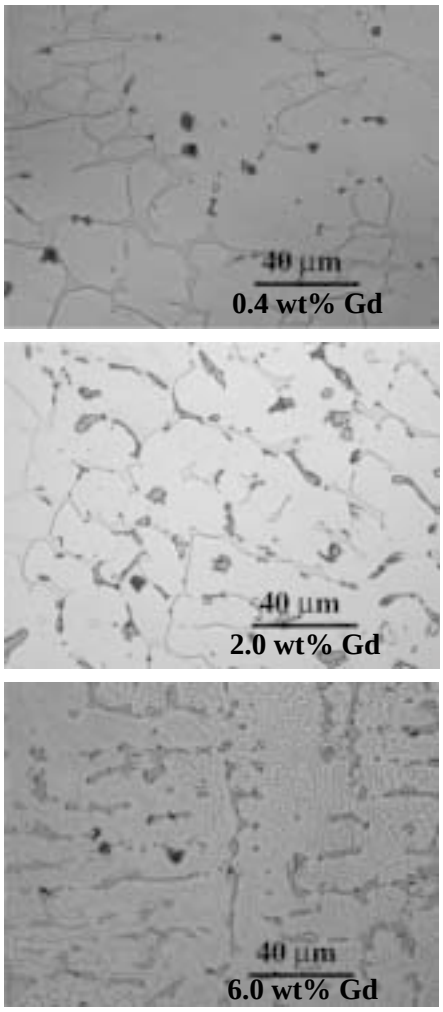
Purpose
Safe, long-term storage of the U.S. Department of Energy (DOE)-owned spent nuclear fuel requires a corrosion resistant, long-lasting material that absorbs neutrons emitted by spent nuclear fuel. The National Spent Nuclear Fuel Program is investigating gadolinium-alloyed stainless steels for potential use in neutron absorber components.

Project Description
The National Spent Nuclear Fuel Program is performing research on low-cost, highly effective gadolinium-stainless steel alloys. The material must provide suitable neutron absorption and long-term corrosion resistance while providing the required mechanical properties and processing response. This alloy may be used for the internal baskets of the standardized DOE spent nuclear fuel canister and serve the following three functions: structural support of the fuel assemblies, spent nuclear fuel geometry control, and nuclear criticality safety.

Gadolinium has a significantly higher neutron absorption cross section than boron, which may make it a more effective alloy addition for neutron absorption. In addition, gadolinium-containing constituents in the alloy may not dissolve as quickly as chromium borides in the presence of water when the material corrodes. Gadolinium is also readily available and reasonably priced.

Characterization of gadolinium-stainless steel alloys will be performed to establish an American Society for Testing and Materials (ASTM) material specification. The specification is needed for subsequent American Society of Mechanical Engineers code approval and the Nuclear Regulatory Commission approval for subsequent use by the nuclear industry.

The National Spent Nuclear Fuel Program is evaluating gadolinium-stainless steel alloys for primary processing behavior, microstructure, mechanical properties, weldability, and corrosion behavior. This work is intended to provide a foundation



Microstructures of 316L with different gadolinium contents.

INEEL
Idaho National Engineering & Environmental Laboratory
BECHTEL BWXT IDAHO, LLC

Gleeble 3500, a high-temperature metals test instrument, is used to establish the optimal forging temperature for 316L stainless steel alloyed with gadolinium.

for continued development and qualification of gadolinium-alloyed stainless steels if the initial evaluations prove promising.

Benefits

Gadolinium is a readily available, relatively low-cost material that has a significantly higher neutron absorption cross section than boron. Its structure encourages linear loading that maximizes uniform neutron absorption. Finally, gadolinium is almost corrosion-resistant, making it an effective neutron absorber over long time periods. With these characteristics, gadolinium-stainless steel alloys can potentially provide the nuclear criticality safety required for interim storage, transport, and final disposal of spent nuclear fuel.

Unique Capabilities

Although it has the highest thermal neutron absorption cross section, gadolinium has not historically been used because of its lack of availability. A substantial increase in the mining of rare earth elements over the last fifteen years has resulted in substantial availability of gadolinium as a byproduct material.

Gadolinium-stainless steel alloy materials may be used as components in spent nuclear fuel packages. This advanced neutron-absorbing material could provide long-term corrosion resistance and provide for optimum neutron reduction.

Current Issues

Sophisticated modeling based on established chemistry and natural analog systems must be used to guarantee the stability of a neutron-absorbing material over a long time period. Regulators must acknowledge the models before the neutron absorbers can be used.

Project Status

The feasibility of alternative approaches for neutron absorber deployment has been evaluated, and development of specific material forms is now in progress. Initial gadolinium-stainless steel development has been performed, and code development is ready to begin.

Fiscal Year 2000
Evaluate feasibility, develop necessary test and analysis programs, initiate development

Fiscal Year 2001
Initiate or continue materials development on approved materials. Initiate code development

Fiscal Year 2002
Finalize initial materials development. Initiate corrosion testing and finalize codes and standards

Fiscal Year 2003
Finalize corrosion tests and formally adopt materials for use in packages

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