CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: The 132nd Annual Meeting & Exhibition of the Minerals, Metals & Materials Society
Project No. 20.06002.01.081; AI 06002.081.308

DATE/PLACE: March 3–6, 2003
San Diego, California

AUTHOR: Y-M. Pan

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PERSONS PRESENT:

The conference was attended by more than 3,500 participants from all over the world. There were 48 symposia with a record number of 1,900 papers presented. In addition to the Center for Nuclear Waste Regulatory Analyses (CNWRA) staff, A. Csontos from the U.S. Nuclear Regulatory Commission (NRC) was also present.

BACKGROUND AND PURPOSE OF TRIP:

The purpose of staff attending this conference was to present a paper in the Mike Meshii Symposium on Electron Microscopy: Its Role in Materials Research and to keep up with the latest advances in the areas of nuclear materials, materials lifetime prediction, and computational materials science.

SUMMARY OF PERTINENT POINTS:

Technical Program

The technical symposia that were of particular interest to the NRC high-level waste program included (i) Actinide Materials: Processing, Characterization, and Behavior; (ii) Microstructural Processes in Irradiated Materials; (iii) Materials Lifetime Science and Engineering; and (iv) Mike Meshii Symposium on Electron Microscopy: Its Role in Materials Research. The summary provided in this report includes CNWRA staff presentation and other presentations on topics relevant to the high-level waste program.

The author of this report presented a paper titled Phase instability and corrosion of Alloy 22 as a high-level nuclear waste container material. In this paper, the effect of metallurgical stability on localized corrosion susceptibility was evaluated using corrosion tests and analytical electron microscopy measurements. Results obtained from this study indicate that thermal exposure at 870 °C [1,598 °F] for 5 minutes resulted in the formation of topologically close-packed phases at grain boundaries; however, no significant alloy depletion was detected in the matrix adjacent to the precipitates nor in the grain-boundary regions between precipitates. Nevertheless, precipitation of topologically close-packed phases as a consequence of thermal exposure has a detrimental effect on localized corrosion of Alloy 22. Significance of phase instability on corrosion of Alloy 22 was discussed. Finally, the observed adverse effect of short-term thermal exposure of Alloy 22 to elevated temperatures warrant additional analyses that assess the entire fabrication and closure sequence on the phase instability of Alloy 22 and the possible deleterious effects on localized corrosion and stress corrosion cracking. A question was raised by R. Rebak (Lawrence Livermore National Laboratory) regarding whether thermal exposure at lower temperatures will induce alloy depletion. It was clarified that development of pronounced alloy depletion is unlikely because precipitation of topologically close-packed phases is governed by substitutional element diffusion. In addition, the microstructure observed in the 5-minute aged specimen represents the initial stage of precipitation, and replenishing of any depleted region is not anticipated to occur.

There were four sessions in the symposium on Actinide Materials: Processing, Characterization, and Behavior, including plutonium, advanced fuel cycles, and two sessions of advanced fuels and materials. The symposium was initiated with a keynote lecture by S. Hecker (Los Alamos National Laboratory), titled An overview of plutonium: metal, ceramics, and chemistry. Hecker first described the role of plutonium with respect to peace and prosperity or terrorism and proliferation. For metallic plutonium it's the nature of the 5f electrons that makes plutonium the most complex element. Plutonium exhibits numerous phase transformations with temperature, pressure, and chemistry and is highly reactive in moist air and strongly reducing in solution, forming multiple compounds and complexes in the environment and during chemical processing. Potential aging effects in plutonium alloys include surface reactions, metallurgical changes, and self-irradiation effects. On the other hand, PuO_2 is the most common plutonium ceramic, and its properties are determined by the crystal lattice and defect structure instead of the 5f electrons.

The symposium on Microstructural Processes in Irradiated Materials was the fifth in a series of symposia held every two years. There were nine sessions, including two poster sessions, in this symposium focusing on the microstructural changes in solids during ion, electron, neutron, gamma ray or x-ray irradiation. L. Wang (University of Michigan) presented an invited talk on Radiation effects in nuclear waste glasses. Wang discussed irradiation damages in high-level waste glasses and ceramic wasteform and presented their recent experimental results on this subject. His presentation included the results from a new study regarding electron irradiation damage in borosilicate glasses, in which boron was observed to be segregated but sodium depleted as a result of irradiation. The observed phase separation behavior may decrease the chemical durability on radiation resistance of the glasses. This presentation was concluded with several highlight points. Radiation can induce chemical disordering, amorphization, phase decomposition, and nanocrystallization in nuclear waste ceramics. Ionized radiation with electron beam can induce phase separation, bubble formation, and volume reduction in nuclear waste glasses. Finally, radiation effects can greatly affect the chemical durability, ion exchange capacity, and other physical or chemical properties of the nuclear waste materials.

G. Was (University of Michigan) gave a review presentation on Role of irradiated microstructure and microchemistry in irradiation assisted stress corrosion cracking. He discussed numerous studies regarding irradiation assisted stress corrosion cracking of austenitic alloys in high temperature water, both in the laboratory and in service, over the pass two decades. The changes in microstructure, microchemistry, and hardening in austenitic alloys as a result of irradiation were found to affect cracking susceptibility individually and collectively. The influence of stacking fault energy on stress corrosion cracking was also discussed. Low stacking fault energy (below 50 mJ/m^2) and irradiation was observed to promote localized deformation that results in deformation in the grain boundaries, followed by initiation of a grain-boundary crack. He concluded that deformation mode may be a key factor in irradiation assisted stress corrosion cracking.

The four-session symposium on Materials Lifetime Science and Engineering addressed the damaging processes that control the lifetimes of structural materials with emphasis on the synergistic interactions between environmental and mechanical effects. R. Jones (Pacific Northwest National Laboratory) presented an invited talk titled Corrosion damage functions and life prediction. Several types of corrosion damage that lead to reduced operational lifetimes by stress corrosion cracking, hydrogen induced cracking, and corrosion fatigue were discussed. In case of an operating pipeline, the transition to long crack conditions was attributed to a sequence of events including the stages of incubation, initiation, crack coalescence, and growth of a long crack, as illustrated in a crack velocity versus time plot. A critical step in defining a corrosion damage function for stress corrosion cracking was determined. The corrosion damage function is related to the conditions that produce crack growth such as a pit or other stress concentrator plus the crack growth that results in the stress intensity rising to a value equal to the fracture toughness of the materials.

TMS Activities

The author of this report joined the Corrosion and Environmental Effects Committee and attended the committee meeting for future programming and symposia planning.

IMPRESSIONS/CONCLUSIONS

This conference was organized with a variety of symposia on emerging and hot topics. More than 3,500 attendees came from industry, academia, and government agencies. The participation at the meeting was an excellent avenue to present the work conducted at the NRC and CNWRA. Attending this conference also provided the opportunity to keep current with the topics relevant to the NRC high-level waste program.

PROBLEMS ENCOUNTERED:

None.

PENDING ACTIONS:

None.

RECOMMENDATIONS:

Continued participation in future TMS meetings is highly recommended.

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3/18/2003
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