Environmental Management Science Program

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Optimization of Thermochemical, Kinetic, and Electrochemical Factors Governing Partitioning of Radionuclides during Melt Decontamination of Radioactively Contaminated Stainless Steel

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Research Objective

Melt decontamination of radioactive scrap metal could convert a disposal liability into a final product that would reduce the total volume of material necessary for burial and save substantial material costs. The goal of this project is to optimize a melt decontamination process through a basic understanding of the factors which govern the partitioning of various radionuclides between metal, slag, and gas phases. Radionuclides which are captured by a slag phase may be stabilized by promoting the formation of synthetic minerals within a leach resistant matrix. The main focus of this project is the application of electroslag remelting (ESR) toward cleanup of surface contaminated stainless steels.

Research Progress and Implications

This report summarizes work accomplished after 9-months of a 3-year project. Activities are ongoing at Sandia National Laboratories and at Boston University.

At BU, Prof. Uday Pal and his group conduct research to develop a fundamental understanding of thermochemical and electrochemical behaviors of slag/metal/radionuclide surrogate systems. This work combines experimental characterization and thermochemical modeling of these high temperature systems.

First year goals are: 1) to measure and characterize equilibrium partition functions of the surrogate contaminants between the slag and the metal as a function of the temperature and atmosphere. This will include measurements of the rate of approach to equilibrium by determining the partition function as a function of time. The results will be used to model the slag-metal reaction kinetics; and 2) to measure and characterize ionic and electronic conductivities or resistivities of the different slags. The electrical conductivity of the slag will be measured as a function of temperature and oxygen partial pressure.

A laboratory facility has been set up to perform these high temperature measurements; significant effort has gone to development of the necessary crucibles, electrochemical cell configuration, and other experimental techniques for high temperature measurements in the corrosive fluoride-containing molten slags used in ESR. Initial thermochemical modeling began to describe these systems' behaviors.

At Sandia, the goals are to develop models, experimental characterization, and controls for ESR decontamination in a prototype industrial scale furnace. A special vertically-split ESR ingot mold was designed, fabricated, and instrumented with thermocouples. This mold allows detailed examination of slag skin and slag cap structure and chemistry. Process modeling of the ESR furnace has been performed to evaluate the effects of slag chemistry variations on furnace electrical and thermal performance; these will be validated in upcoming experimental melts.

This project is connected with other on-going projects in ESR decontamination through Sandia. A joint effort between Sandia and K-26 in Krasnoyarsk, Russia, funded by the International Proliferation

Prevention Program, is setting up an ESR furnace there to melt surface-contaminated radioactive stainless steel piping. Another project, funded by the Amarillo National Resource Center for Plutonium, supports ESR furnace controls research by Prof. Joe Beaman at the University of Texas in Austin in association with Sandia.

Planned Activities

At Boston University, high temperature slag/surrogate equilibrium measurements and electrical conductivity experiments will begin this summer and continue into 1999. Thermochemical modeling of slag/radionuclide surrogate interactions will continue, utilizing the new experimental data for verification.

At Sandia, over the summer a series of ESR furnace experiments will study effects of slag composition on surrogate pickup by the slag. These fully instrumented melts will measure slag temperatures and furnace thermal performance to help benchmark thermochemical reaction models as well as the ESR furnace melting and solidification model. Solidified slag skin and slag cap structures and compositions will be determined, along with surrogate chemical partitioning between the slag cap and slag skin.

Other Access to Information

Publication and Presentation: Eric Schlienger, Joe Michael, James Van Den Avyle, Davis Melgaard, Greg Shelmidine, “Solidification Sequence as a Means of Containing Radionuclides During Melt Decontamination International Conference on Incineration and Thermal Treatment Technologies, Salt Lake City, May 11-15, 1998