WSRC-MS-97-0552
CONF-971125--

Vitrification of Actinides Contained in Platinum Alloy Vessels

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A document prepared for AMERICAN NUCLEAR SOCIETY WINTER MEETING 1997 at Albuquerque, NM, USA from 11/16/97 - 11/20/97.

DOE Contract No. DE-AC09-89SR18035

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VITRIFICATION OF ACTINIDES CONTAINED IN PLATINUM ALLOY VESSELS

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Introduction

While the use of platinum and platinum alloys for melting glass has a history dating back hundreds of years, its use for vitrification of radioactive materials has developed only within the last few years. Platinum-rhodium alloy has recently been utilized for both the containment and heating of small quantities of actinide materials during the vitrification process. Small, platinum alloy, melter systems are planned for use at the Savannah River Site (SRS) to vitrify residual actinide materials. The primary example is the SRS program to vitrify the contents of F-canyon Tank 17.1. This tank contains the majority of americium (Am) and curium (Cm) in the DOE complex.[1] Other actinides may be vitrified in the future and include uranium (U) and plutonium (Pu).[2]

Examples of Platinum Vitrification Systems

The process presently under development for the vitrification of the 12,000 liters of 4 normal nitric acid solution of Am and Cm would produce approximately 300 kg of glass. There are about 10 kg of americium-243 emitting 1800 Curies and 3 kg of Curium-244 emitting about 210,000 Curies. The thermal energy generated from the nuclear activity of the total actinides amounts to about 7 kW/hr. The vitrification process would feed the actinide solution adjacent to a stream of glass powder inside a rectangular resistance heated platinum-rhodium vessel.

These small platinum alloy melters or "bushings" are heated by the passage of large electrical currents (thousands of amps) through the end terminals and into the platinum sides and heater screens within the bushing. This type of resistive heating has been used for many years in the continuous glass fiber industry.[3] For the vitrification of the Am/Cm material the nitric acid solution is evaporated to the off-gas system leaving the Am/Cm solids to melt into the glass powder and form a lanthanide borosilicate glass. After melting the glass exits the bushing through a drain tube controlled with indirect heating or cooling. The glass flows into stainless steel cans which after filling will be sealed and decontaminated prior to shipment to Oak Ridge Heavy Element and Advanced Neutron Facility for further processing.

Another recent use of platinum alloy is for the vitrification of excess plutonium-uranium oxide remaining from the U.S. weapons program. The Pu/U oxide would be thoroughly ground and mixed prior to feeding to an inductively heated cylindrical platinum-rhodium crucible. A platinum alloy stirrer will be used to enhance dissolution of the oxides into the glass. A platinum drain tube will again be used to control flow from this melter. After filling, the stainless steel cans will be sealed, decontaminated and sent to the Defense Waste Processing Facility. High level waste glass will be poured into the canister containing the arranged Pu/U cans. The canisters would eventually be sent to a National Repository for storage.

Advantages and Limitations of Platinum Systems

The platinum alloy vitrification systems appear to offer an advantage for the vitrification of specialty nuclear materials and specialty nuclear materials and waste streams. These advantages include:

- Platinum alloys can be used to fabricate small, specialized melter systems and although the cost of the metal is quite high the increased life and simplicity makes its use desirable,
- Platinum alloy melters can be formed into criticality safe dimensions,
- The platinum alloys systems have excellent glass melt and acid resistance.
- The platinum bushings are more adaptable to thermal cycling than most glass melting systems.

While the platinum alloy systems appear to meet many of the requirements for special vitrification materials, the following cautions are important for successful operation:

- The temperature limitations of these alloys are critical with the common alloys of platinum-rhodium having melting points between Platinum (1770°C) to Platinum-20% Rhodium (1900°C),
- The thermal energy for vitrification is related to the metal thickness, therefore, control of metal purity and fabrication is an important consideration,
- Oxidizing conditions should always be maintained to protect the metal from contact with reduced metals, etc. The introduction of reducing materials e.g. carbonaceous materials which can reduce silica or transition metals should be avoided and will damage platinum by forming low temperature alloys
- At high temperatures the alloys are quite soft and high temperature creep can be a problem. This can be compensated somewhat with the use of special oxide grain stabilized platinum alloys.

References

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