“Error! Reference source not found.

The INL is a U.S. Department of Energy National Laboratory
operated by Battelle Energy Alliance.

1. Background

Uranium alloys have been used in a number of past reactors, most recently in the Experimental Breeder Reactor-II, before it was shut down in 1994. Since that time, metallic fuel has been proposed for a number of advanced reactors such as TerraPower's Natrium and OKLO's Aurora reactors. Traditionally metallic fuels have been produced using the counter gravity injection casting (CGIC) technique using one time use quartz molds, as shown in Figure 1 below. In this method the uranium and alloy constituents are melted in a crucible with the quartz molds, which have previously been coated with a thin layer of zirconium oxide, suspended above the crucible. During the casting cycle the furnace chamber, including the quartz molds, is evacuated. After evacuation the open ends of the molds are submerged in the melt, the furnace rapidly pressurized, and molten alloy is forced up into the molds. As the furnace cools the molds are withdrawn from the melt. The process is shown schematically in Figure 1. The molds are then removed from the furnace and the quartz molds shattered to remove the fuel slug. As the molds are shattered small amounts of uranium metal adhere to the molds. This uranium must be accounted for to meet uranium tracking and safeguard requirements. Additionally, the metal, glass, and dust mixture accounts for a significant amount of the non-directly recyclable scrap. For advanced reactors the uranium economy is very important and it will be necessary to recover as much uranium as possible for future recycling. Figure 2 provides an example of the glass and dust waste which accounts for a significant portion of the not directly recyclable scrap during the EBR-II fabrication process.

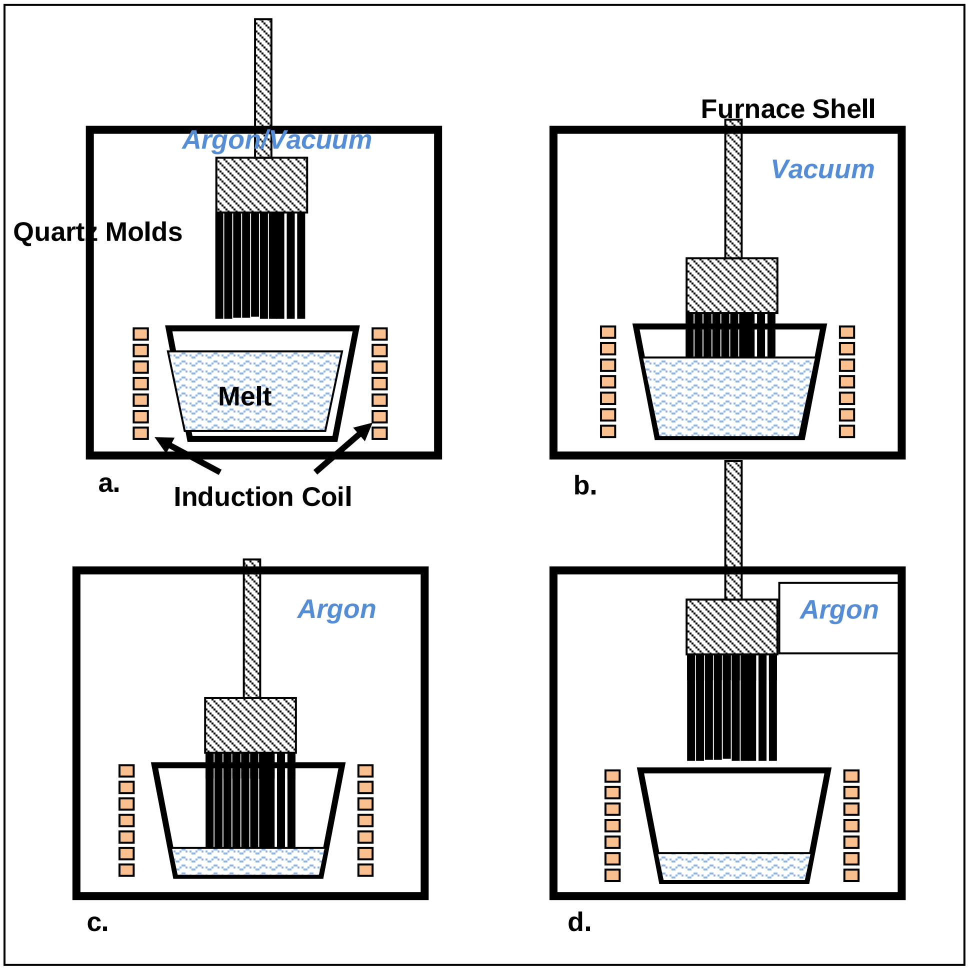

Figure 1. Schematic representation of the CGIC process.


Figure 2. Example of glass and dust scrap which includes some metallic portions.

2. Purpose / Objectives

To design and demonstrate a system capable of separating quartz, zirconium oxide dust metallic particles. After demonstration, provide a report showing the design, process, results, and possible methods of scale-up for industrial use.

3. Anticipated Benefits

Metallic fuel has been selected as the driver fuel for several advanced reactors. Most of the fuel fabrication process designs call for a process that is very similar to the process used during EBR-II fabrication, which did not separate fine fuel particles from the glass and dust waste streams. By designing and demonstrating a system capable of separating "fuel" particles from non-fuel particles the overall waste production is reduced and the valuable fuel can be recycled.

4. Summary of Objectives:

1) Design a separation system (mechanical, electrical, and instrumentation, and control system as necessary) to separate metallic particles (surrogate fuel) from quartz and zirconium oxide dust. The initial mixture should be made up of mostly quartz and zirconium dust with no more than 10% (by mass) metallic particles. The batch size shall be not less than 2 kg, with a processing time of less than 15 minutes per batch.
2) Fabricate the designed system and process several batches of dust and powders to determine recovery efficiency, time, and lower limits of usable metallic fractions in the dust.
3) Provide an analysis of possible scale up options and assumed throughout rates.

5. Deliverables

At the end of the project (Spring Semester 2024) a final report detailing the design, any accompanying analysis, and results processing and optimization study shall also be submitted to the sponsor.

6. Budget

The materials and supplies budget for this project is $5042.

7. Applicable Engineering Disciplines

Mechanical Engineering, Electrical/Computer Engineering, Biological Engineering, Computer Science