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High-Assay Low Enriched Uranium Pyroprocessing and Electrometallurgical Treatment at the Fuel Conditioning Facility

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Changing the World's Energy Future

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Idaho National Laboratory
Idaho Falls, Idaho 83415

http://www.inl.gov

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High-Assay Low Enriched Uranium Pyroprocessing & Electrometallurgical Treatment at the Fuel Conditioning Facility

Susan L Steffler & Anselmo Mata <> Idaho State University Energy Systems Technology & Education Center <> Mentor: Jeff Wass <> EBR-II Used Fuel Treatment

Abstract

The Fuel Conditioning Facility (FCF) fulfills part of INL's mission by reprocessing irradiated sodium-bonded fuel from the EBR-II reactor. They also participate in research to further explore the fuel cycle for recovery of fuel from a variety of current reactors in use today. The fuel cycle of a nuclear reactor under the current non-proliferation act leaves unused fuel in the spent fuel rods. The rods are safely stored until their fuel can be recovered.

Fuel recovery from the EBR-II fuel pins has several steps to separate the uranium from the salts. The pyroprocessing technology involves high - temperatures, chemical, and electrochemical methods for separating the unused uranium from the salts, fission products, and used fuel. The recovered uranium is then remixed and formed into ingots or regulus with an enrichment of < 20% U-235. This final product can be a source to fuel current nuclear reactors as well as research and development for future nuclear reactors.

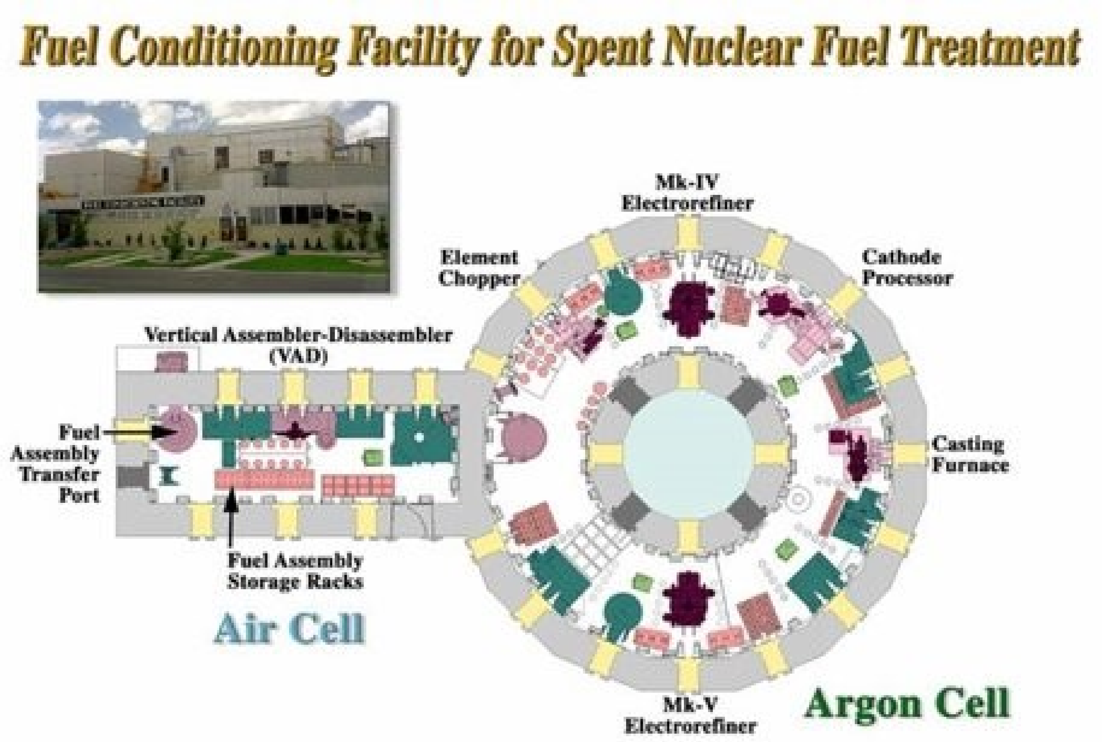

Figure 1: FCF Building # 765. Air cell and the argon cell

The pyroprocessing of used fuel performed at FCF produces a high-assay low enriched product that is not produced anywhere else in the world. The high purity uranium product is valuable for research and development.

Pyroprocessing Technology

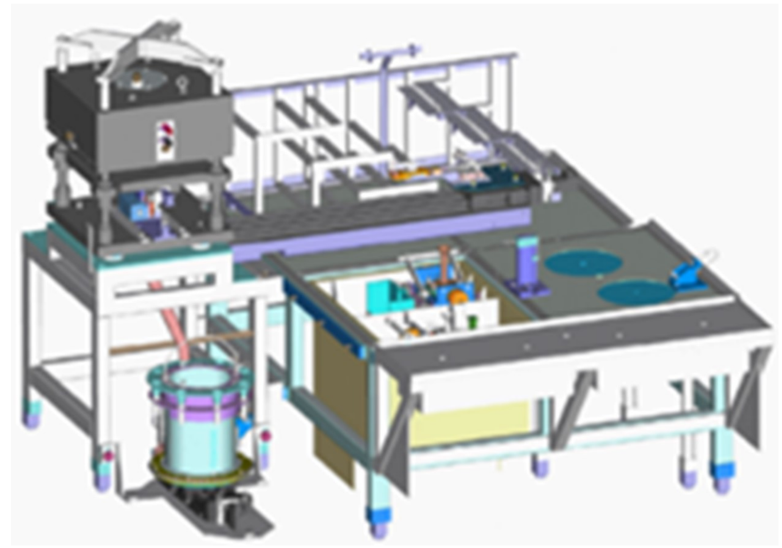

Figure 2: Mk-IV Element Chopper

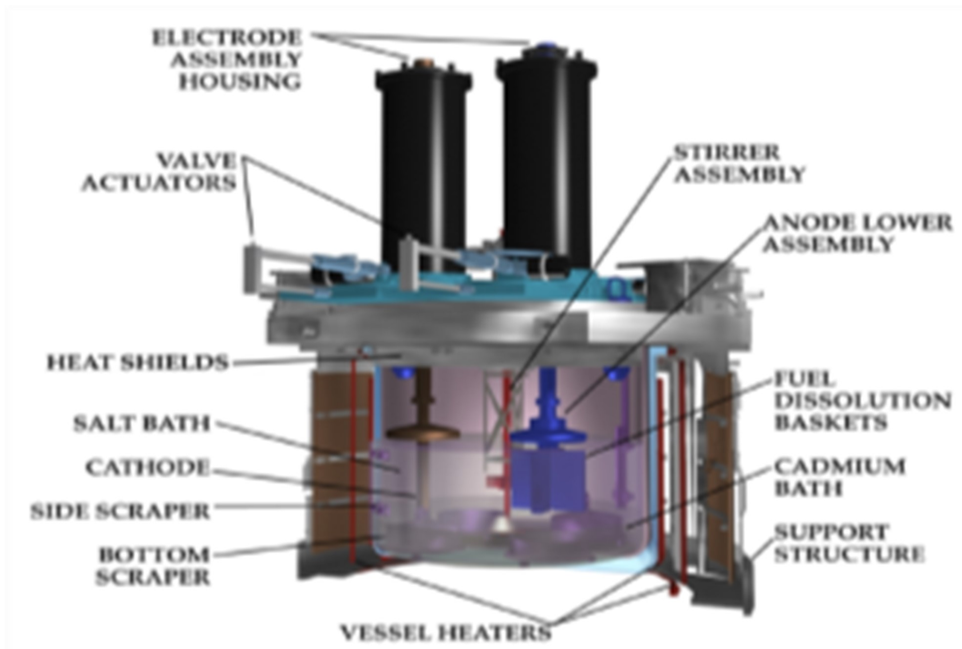

Figure 3: MK-IV Electrorefiner

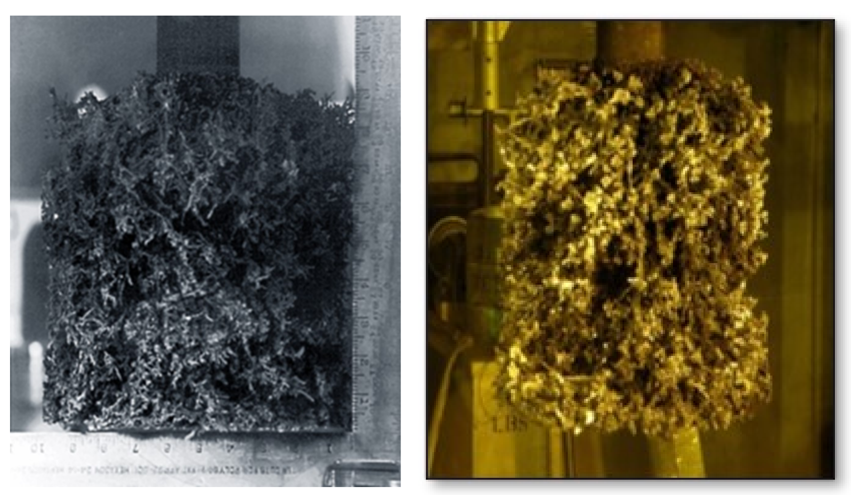

Figure 4: Dendrites, Uranium Metal

The dendrite is harvested into a crucible and transferred to the cathode processor.(fig. 4) Dendrite contains approximately 8 kg of uranium metal and 2 kg of entrained salt.

The element chopper process organizes, counts, and sections the fuel pins and deposits them in the anode basket. (fig.2) The segments are typically ¼ - ¾ inches long. The anode basket is filled with ~12 kg of driver element segments and then it is ready to begin the process of separating the uranium from the sodium and stainless-steel cladding in the electrorefiner.

The electrorefiner process separates the heavy metals and fission products from the driver element segments in the anode basket. (fig. 3) This process uses an electrochemical reaction and is collected on the cathode. The elements are broken down in the molten salt by pyrochemical reaction. The ER is operated at 500˚C. The final product is collected on the cathode side, with the uranium metal in dendrite form.

The cathode processor separates the uranium from the remaining salts through a vacuum distillation. (fig. 5) The cadmium vaporizes at approximately 550˚C and the salts at approximately 1200˚C. They collect in the receiving crucible at the bottom leaving the uranium in the process crucible. The uranium is now in the form of an "ingot". At this stage, the ingot has been down blended to lower the enrichment and is now ready to be transferred to the casting furnace (CF).

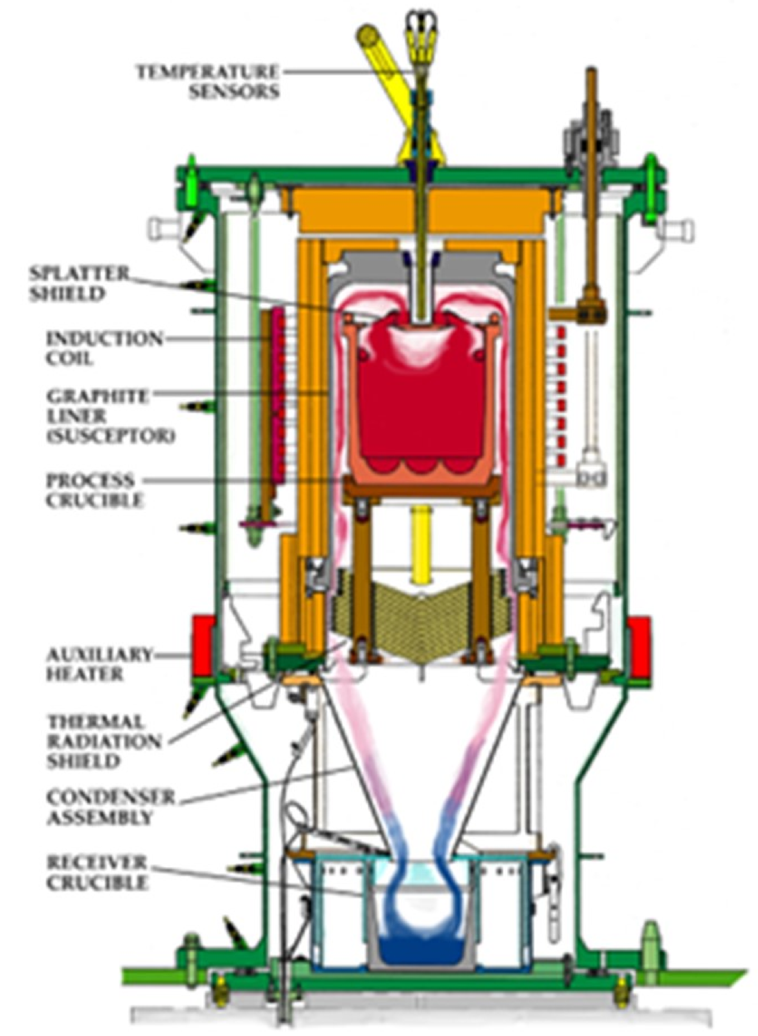

Figure 5: Cathode Processor

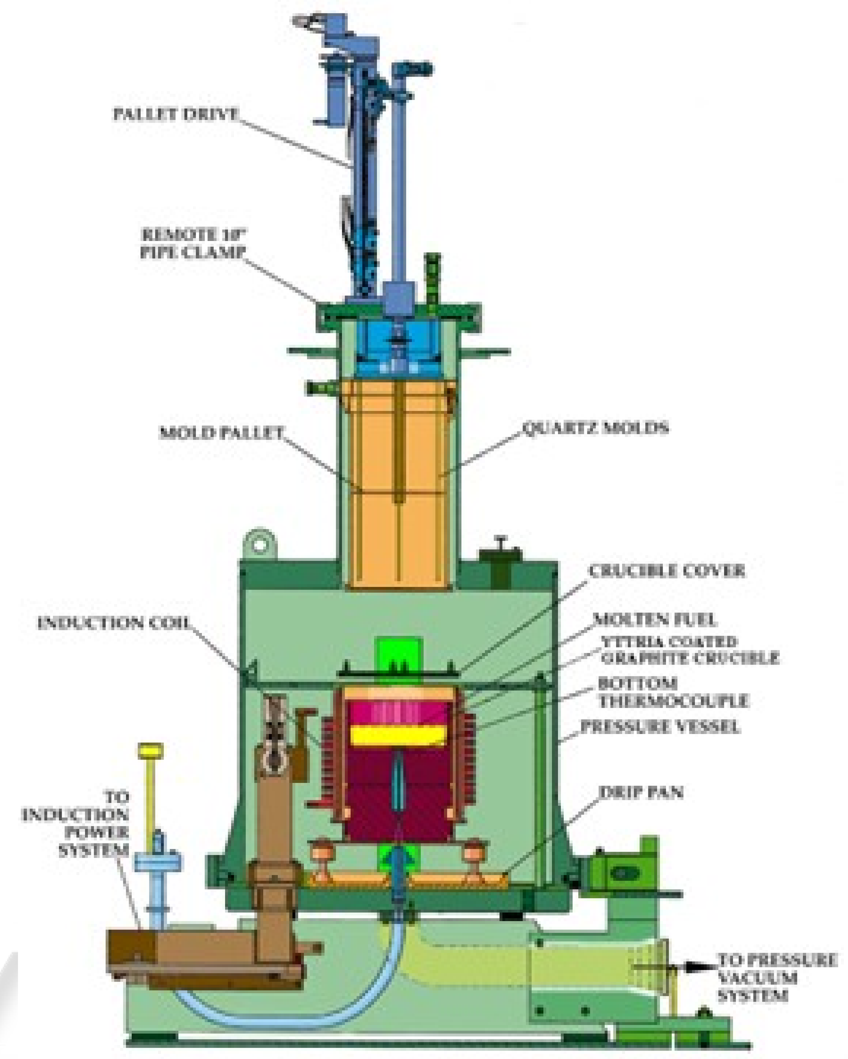

Figure 6: Casting Furnace

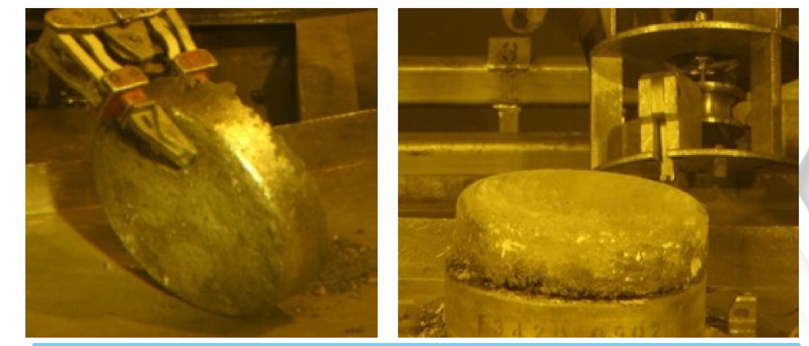

Figure 7: Ingot

(Fig. 7) The weight of the uranium ingot after the distillation of salt and cadmium, is approximately 25kg. This includes the addition of depleted or natural uranium metal added to reduce the enrichment.

Figure 8: Reusable Crucible

The crucible for the regulus has 5 slots which make each reguli 5kg each. (fig. 8)

The casting furnace is where the final down-blending for the desired enrichment percentage takes place as well as the final casting. (fig.6) The casting furnace melts the uranium metal to verify a homogonous product using pin sampling. The final uranium metal product is recast in the cathode processor in a cone shape called "regulus" or "reguli". (fig. 9)

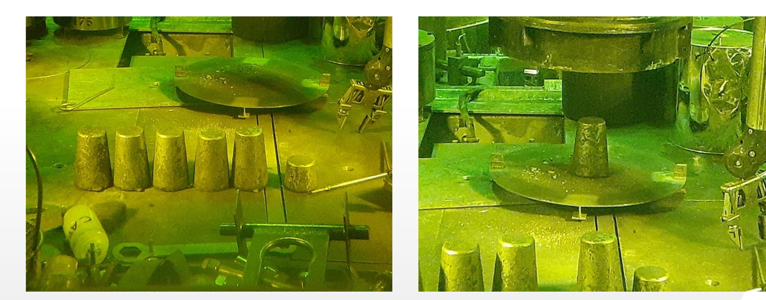

Figure 9: Regulus

References
Figure 1, 2, 3, 4, 5, 6, 7:
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