CRIEPI News 363

General view of the cell for electrorefining experiment

Reprocessing without nitric acid solution nor organic solvent

Development of pyro-process fuel cycle technology

— Recovery of uranium and plutonium mixture by means of molten salt electrorefining was carried out with anodic dissolution of U-Pu-Zr fuel alloy —

1. Electrorefining, which is the main process of pyro-reprocessing
2. Fabrication of electrorefining installation operated with manipulator
3. Electrorefining experiment with metallic fuel

● **Brief Note: Kensuke Kinoshita**, Research Scientist, Pyro-process fuel cycle project, Komae Research Laboratory

Electrorefining, which is the main process of pyro-reprocessing

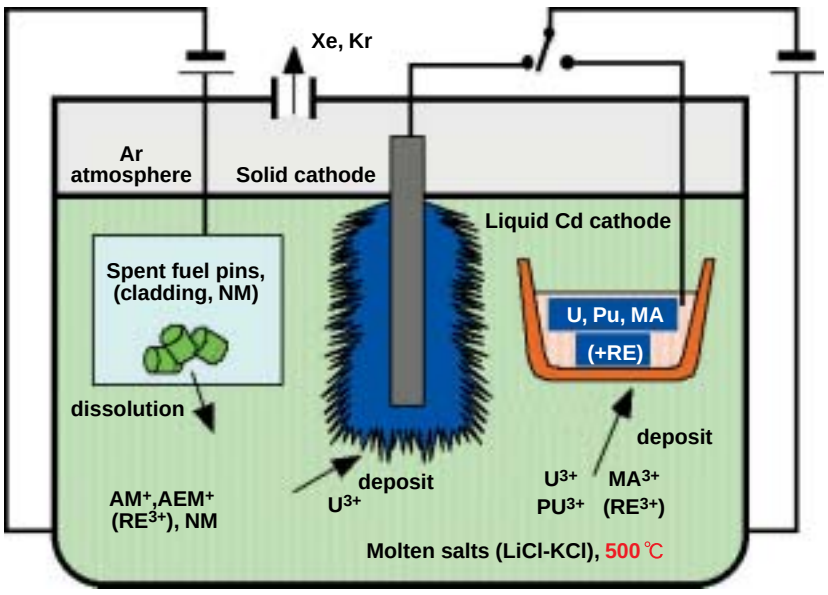
Metallic fueled FBR and pyro-process fuel cycle, which has been developing in CRIEPI, is the advanced nuclear fuel cycle technology with the low cost, high potential of nuclear nonproliferation and low impact to the environment. An experimental installation was set up and experiments were carried out at EC-JRC Institute for Transuranium Element (ITU) in Karlsruhe, Germany in order to demonstrate the electrorefining technology with metallic fuel alloy containing uranium (U), plutonium (Pu), and zirconium (Zr). As a result, Pu and U were recovered on a cathode simultaneously with anodic dissolution of U-Pu-Zr fuel alloy for the first time. It is expected that this achievement will be an important step towards the development of pyro-process fuel cycle.

Electrorefining technique for metallic fuel

Spent metallic fuel is reprocessed by applying pyro-process, in which any aqueous solutions are not used. U and Pu could be recycled in the simple and compact process which has advantage of the low cost, high potential of nuclear nonproliferation and low impact to the environment from the waste disposal. U and Pu are recovered by means of electrorefining technique, in which spent metallic fuel in a metal basket is served as anode (+) and solid steel rod or liquid Cd poor in a ceramic crucible as cathode (-) in a molten salt bath at 500℃.

Experiments with metallic fuel

With a current applied between the two electrodes, fuel alloy is dissolved from the anode into molten salt and U and Pu are recovered at a cathode. No experimental study has been, previously, carried out with anodic dissolution of U-Pu-Zr fuel alloy and cathodic deposition. This kind of information is indispensable for practical application of the electrorefining, therefore, CRIEPI decided to construct an experimental installation that is capable of handling U, Pu and minor actinides by the collaboration of ITU.



AM⁺ : Alkali (Cs Rb, etc.)
AEM²⁺ :Alkaline earth (Sr, Ba, etc.)
RE³⁺ : Rare earth (Nd, Ce, etc.)
MA³⁺ : Minor actinide (Np, Am, Cm, etc.)
NM : Noble metal (Pd, Rh, etc.)

Figure 1 Process image of electrorefining for recovery of U and Pu

Fabrication of electrorefining installation operated by using manipulator

Fabrication of experimental cell

The experimental installations in ITU are shown in photographs on the cover page (general view) and Fig.2 (inside). The experimental cell is filled with high purity argon gas controlled with less than both 10 ppm of moisture and oxygen in order to use kinds of metals and chlorides with high purity. The cell are set in the usual laboratory for experiment with unirradiated metallic fuel alloy and then it will be transferred to the hot cell area shielded with the lead for experiments with irradiated metallic fuel.

Fabrication of electrorefining installation

An electrorefining installation in the experimental cell was newly prepared for operation in a glove box by using manipulator. Since a manipulator operation is forced to the limit on handling of various devices, a number of improvements are made, for example lifting the unit by crane, replacement of the cathode as an integrated unit, simplified and rigid mounting of the agitation motor without a screw, and so on.

Figure 2 Electrorefining installation set in the experimental cell

Electrorefining experiment with metallic fuel

Anodic dissolution of metallic fuel

Electrorefining experiments were carried out with U-Pu-Zr fuel alloy. As a result, it is confirmed that the fuel alloy was dissolved uniformly from outside of them and that anodic dissolution was not a determining factor on the rate of electrorefining process. It is also found that Zr was easy to remain around the fuel as a mixture with salt because of less anodic dissolution rather than U or Pu.

Figure 3 U deposit on a solid cathode (Purple color comes from uranium chloride.)

Recovery of U and Pu

Recovery of U onto Solid cathode or recovery of U and Pu into liquid Cd cathode could be done simultaneously with anodic dissolution of fuel alloy. The recovered U turned into lumps containing a large amount of chlorides as shown in Fig. 3 in the coexistence of Pu or Zr, which is different from typical needle-like deposit called dendrites. These results at conditions closer to actual operation are reflected to explore a key parameter towards the development of the pyro-process fuel cycle. We have a plan to carry out experiments with irradiated fuel to demonstrate the electrorefining at the similar condition as a real process. CRIEPI is also developing the pyro-process for applying to oxide fuel from light water rector.

● Brief Note

Kensuke Kinoshita
Research Scientist
Pyro-process fuel cycle project
Komae Research Laboratory

Much effort is required for commercial application of the electrorefining technology. A cooperative research relationship with ITU for a long time expects to make a best use of this experimental cell and installation for demonstration of pyro-process technology.

Central Research Institute of Electric Power Industry

July 2002
Central Research Institute of Electric Power Industry
Public Communications Division
1-6-1 Ohtemachi, Chiyoda-ku, Tokyo 100-8126 JAPAN Phone: +81 3 3201 6601 FAX: +81 3287 2863
E-mail : www-pc-ml@criepi.denken.or.jp http : //criepi.denken.or.jp