

Principal Research Results

Development of Metal Pyro-processing of Spent Nuclear Fuels – Series Process Test Using MOX –

Background

A nuclear fuel cycle consisting mainly of metal fuel fast reactor and pyro-processing is evaluated to be one of the most promising fuel cycle concepts for the next generation. Central Research Institute of Electric Power Industry (CRIEPI) has been performing the R&D of pyro-processing for about 20 years. In 2000, CRIEPI started a collaboration study with Japan Atomic Energy Agency (JAEA) and produced an equipment that can treat uranium and plutonium in series process conditions of main steps of pyro-processing. Both institutes have accumulated a lot of basic data and know-how for designing the industrial process.

Objectives

The pyro-processing is illustrated in Fig.1. The aim of the present study is to elucidate the mass balance of uranium and plutonium in the series process test condition using MOX-fuel as a starting material. The various concerns to be solved for the development of the industrial process were also discussed.

Principal Results

1. Elucidation of process rate for reduction of MOX-fuel

For the reduction step of MOX-fuel, a practical process rate, <6hours, was accomplished in the condition that the particle size of MOX is prepared to be <0.5mm, as indicated in Fig.2.

2. Recovery of U-Pu ingot

An U-Pu alloy ingot, 26g in weight, was recovered after the series process test, as shown in Fig.3. The recovery ratio of U-Pu with respect to the initial amount was around 86%. The loss of U and Pu mainly originated from anode residue in the electrolysis step and re-oxidation in the Cd-distillation step, respectively.

3. Extraction of various concerns among each step for the industrialization of metal pyro-processing

- (1) Reduction⇒Electrolysis: Since the morphology of U-Pu alloy formed by the reduction of MOX-fuel was very porous, the current efficiency significantly decreased to <65% for the anode dissolution. The use of mesh basket for the anode container increased the current efficiency. The condensation of the anode material by pre-heating was also effective.
- (2) Electrolysis⇒Cd-distillation: Two-step distillation was recommended for the increase in the recovery ratio of U, Pu, and Cd, and the protection of re-oxidization of U and Pu. (i) Rough separation of Cd by keeping the Cd-phase liquid after heating, and (ii) thorough separation of Cd in the condition just below the boiling point of Cd. Fig.4 shows the U-Pu products after Cd-distillation.
- (3) Cd-distillation⇒Ingot formation: To increase the U-Pu recovery ratio in the whole process, a re-work step was developed, in which re-oxidized U or Pu was converted to the chloride by the chemical reaction with zirconium tetrachloride. The various residues obtained in the series process test were recovered and converted to chloride. The recovery ratio of U and Pu attained >90%.

Future Developments

In 2006, the metal fuel cycle was selected in Japan as a sub-concept in the R&D program for the advanced fuel cycle. Based on the collaboration study, CRIEPI and JAEA are planning to continue the improvement of each step and the accumulation of various know-hows.

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References

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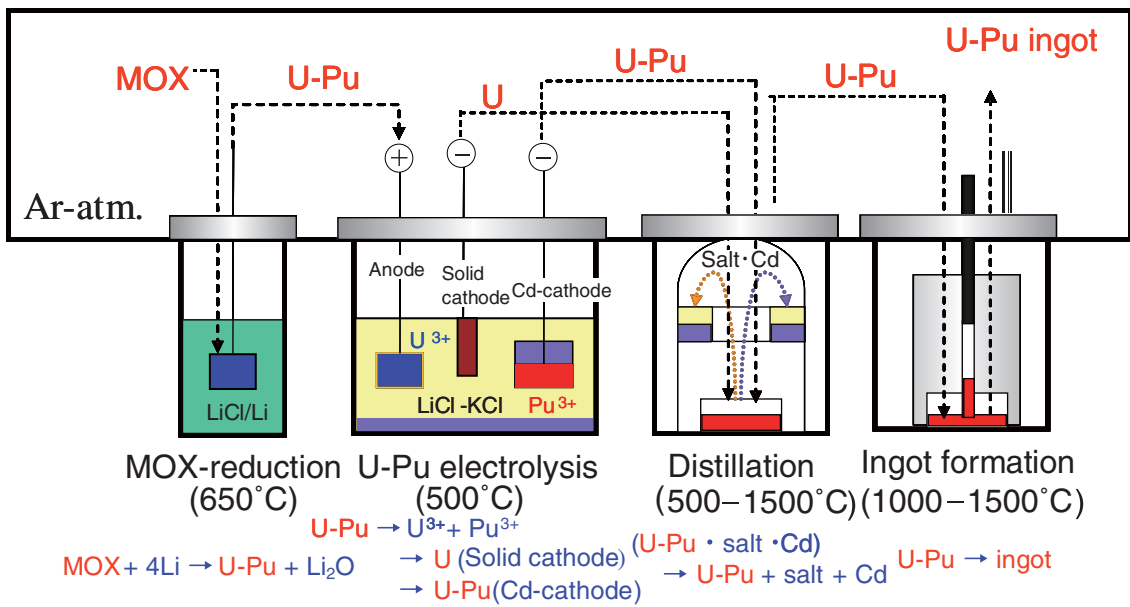


Fig.1 Concept of series process test for metal pyro-processing

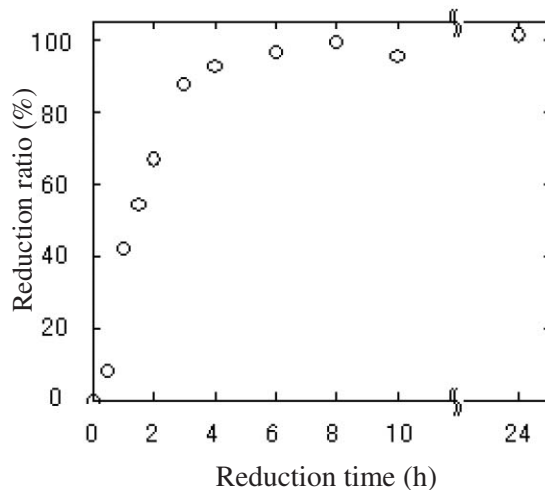


Fig.2 Variation in reduction ratio of MOX-fuel

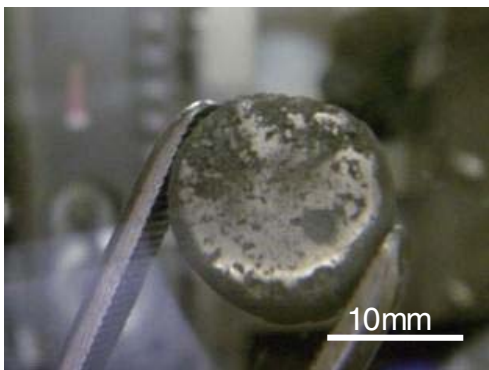


Fig.3 U-Pu alloy ingot recovered after series process test using MOX-fuel as an initial material (26g in weight, 25%Pu contained)

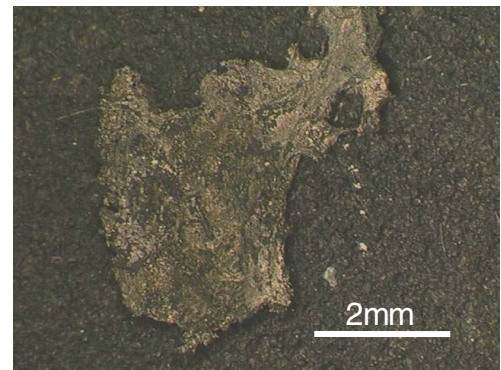


Fig.4 U-Pu alloy recovered after Cd-distillation