TECHNOLOGY OPTIONS FOR FUTURE RECYCLING

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Summary

It goes without saying that recycling of nuclear material is indispensable, not only for the effective use of valuable resources but also to reduce the debt which we may leave to the next generations.

Many developments in advanced reprocessing technologies have been carried out in several countries to deal with the diversification of nuclear fuels. Also technologies derived from reprocessing or other fuel cycle areas have continued to be developed in terms of recycling. Cost effectiveness and waste-free processing are increasingly important factors in the applicable of an alternate recycling policy.

This paper introduces an example of the studies in this field, which has been conducted in Japan and considers the establishment of effective recycling methodologies taking into account the uncertainty of future policy.

Reprocessing using Crystallization

The application of Crystallization techniques to reprocessing was first introduced in 1980s. Since then research has been conducted in several countries, including Japan. This technique, using solubility differences between uranium, plutonium, and other elements at reduced temperature, can recover moderately pure uranium nitrate (UNH) from contaminated solutions.

The bench-scale test results show relatively high decontamination factors and ideal grain size suitable for sedimentation and filtration which indicates that this technique is applicable to any stage of separation processes. In addition, this application, combined with solvent extraction, may also be used in the following applications:

Example A:

- Rough recovery of uranium by crystallization from a solution of dissolved nuclear fuel. More than 80% of uranium will be separated as nitrate (UNH) crystals.
- Consequent recovery of the remaining uranium and plutonium using solvent extraction procedure.

Example B:

- Refining of uranium and plutonium by crystallization after solvent extraction procedure.

Since the crystallization technique requires no extracting solvents and it can treat a high concentration of uranium and plutonium solution, such as MOX fuel or other advanced type fuels, the volume of liquid waste is expected to be significantly reduced when compared to the Purex process. Although the solvent extraction process cannot be eliminated in the above example, it has the benefit that the greater part of separation work can be replaced by this simplified process.

Another feature of this technique is flexibility. Several applications can be considered according to the situations. One example is an application for 'low-decontamination purification' for both uranium and plutonium. In the case of utilization of uranium and plutonium for MOX fuel, high decontamination at the reprocessing plant is not necessary.

Further R&D work will be necessary in order to develop practical applications of this process. In particular in the fields of equipment development to enable continuous process operation including development of process reliability, safety examinations (e.g. criticality safety design for many types of fuel treatments) and evaluation of the safeguards approach (some research has already been started in Japan).

Relevant considerations of fuel recycling

To realize a proper fuel cycle strategy, the technologies applicable to many fuel cycle options are important.

One of the problems for recycling relates to the uranium recovered from the reprocessing plant. Even in the case of complete plutonium utilization, some of the recovered uranium still remains.

As to the conversion technique for UO_3 to UF_6 for the utilization as nuclear fuel via re-enrichment, there are some established methods, which are being used or ready for use (in Japan, a pilot plant test has been carried out).

The utilization of recovered uranium depends upon the contents of ^{232}U and ^{235}U. The ^{232}U daughter nuclides, ^{208}Tl, ^{212}Bi that emit high-energy gamma rays, can be purified at the fluorination stage in a conversion process. However because ^{232}U cannot be eliminated, these daughters will continue to build up. This limits re-use of high burn-up fuel because of low ^{235}U and high ^{232}U content.

In this sense, if the irradiated fuel is low burn-up, recycling via an enrichment plant and a fuel fabrication plant, which are designed for natural-origin uranium, can be done with high purification by a combination of crystallization and solvent extraction. In the case of high burn-up (low ^{235}U, high ^{232}U), storage of recovered uranium may be considered a better strategy. The crystallization technique is also applicable for low-decontamination reprocessing.

Another issue to be considered is the use of depleted uranium. In some cases, interim storage or final storage of spent fuel might be necessary. The depleted uranium could be effectively used for the spent fuel container; using its radiation shielding characteristics to advantages. Research has been conducted in Japan including the development of the conversion processes.

Conclusions

The Crystallization process has many advantageous characteristics when compared to presently used reprocessing technologies and is considered to be a promising candidate for the establishment of innovative nuclear fuel cycles. Many technologies for future recycling options have been discussed and proposed and, by the proper combination of the technologies, the future strategy for the effective use of resources can be established in timely manner.

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