1-5 Research and Development of Advanced Aqueous Reprocessing and Simplified Pelletizing Fuel Fabrication

—Fuel Recycling System (Reprocessing and Fuel Fabrication) for the Next Generation—

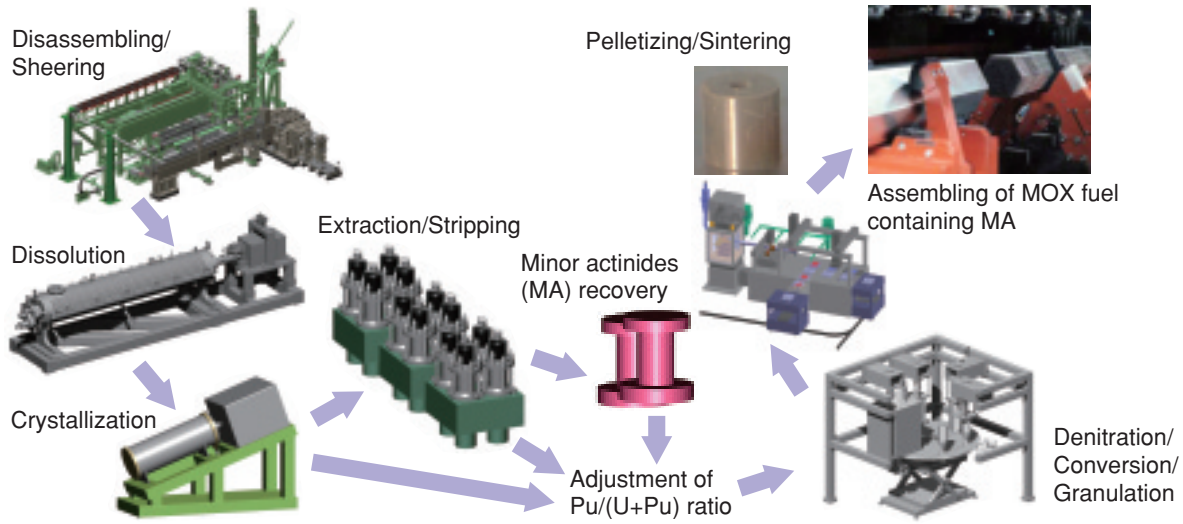

Fig.1-12 The combination of the advanced aqueous reprocessing process and the simplified pelletizing process
The advanced aqueous reprocessing process reduces the amount of aqueous and organic solutions processed in the following extraction/stripping process by the partial separation of uranium (U). Co-extraction and co-stripping of U, neptunium (Np) and plutonium (Pu) eliminate the need for separate partitioning of Pu and purification of U and Pu. Moreover, these fuel products with low decontamination will aid in proliferation resistance.
For adjustment of Pu/(U+PU) ratio, a simplified pelletizing process replaces powder mixing with mixing of solutions: U, U/Pu and minor actinides (MA) solutions. Lubricant-free pelletization and remote fuel fabrication in a cell for producing low-decontamination fuel assemblies and for recycling MA are adopted.

The fast reactor fuel cycle makes possible fuel products with lower decontamination factor (DF) than that of the conventional fuel cycle system. Fig.1-12 shows the key components of a plant based on the advanced aqueous reprocessing process and the simplified pelletizing fuel fabrication process to be used in the fuel recycling system of the next generation. In the advanced aqueous reprocessing process, U, Np and Pu are co-extracted and co-stripped by a single-cycle extraction process. Therefore, partitioning and purification can be eliminated from the conventional PUREX process. In addition, the integration of the reprocessing facility and fuel fabrication facility can contribute to reduction of capital cost.

On the other hand, some modifications of the conventional fuel cycle system may cause increase of capital cost:

-adding the MA recovery process to the reprocessing process,

-adopting remote processing in a hot cell for the fuel fabrication, for extensive-decontamination of fuel products.

It is evaluated that the capital cost of the plant can be reduced to about 50% from that of the conventional fuel recycling plant by optimization of the equipment and application of the above-mentioned new technologies. One concrete example of technology developed for the conceptual design study is minimization of solvent extraction by crystallization. U comprises about 80% of the heavy metal elements contained in the dissolver solution of the spent fuel, and most of the U can be crystallized and separated in the crystallization process. Partial separation of U in the crystallization process greatly reduces the following extraction/stripping of the aqueous and organic solutions. Application of the extraction chromatography leads to the downsizing of the equipment of the MA recovery process. In the simplified pelletizing process, in order to minimize the fuel fabrication processing required in a hot cell, Pu/(U+Pu) ratio is adjusted by mixing a U solution which has been crystallized, a U/Pu solution which has been subjected to extraction/stripping, and a MA solution obtained from the MA recovery, instead of a U and Pu powder mixing process that is a major part of the conventional fuel fabrication process. By these modifications, the fuel cycle system considered in this design study met the requirements for economic competitiveness, efficient utilization of resources, low environmental impact, and proliferation resistance.

The advanced aqueous reprocessing process is considered to be feasible based on the technical information gained at existing plants (Tokai Reprocessing Plant and Rokkasho Reprocessing Plant) although the system and the components for the crystallization and MA recovery should be investigated. Also, feasibility may be attained faster by cooperating with countries that also are developing an aqueous reprocessing process for the next generation. The above fuel fabrication process is also considered to be feasible because the simplified pelletizing is a modified process based on the conventional pelletizing process, although the remote-controlled components have yet to be investigated.

Reference

Japan Atomic Energy Agency and The Japan Atomic Power Company, Feasibility Study on Commercialized Fast Reactor Cycle Systems—Phase Ⅱ Final Report—, 2006, JAEA-Evaluation 2006-002, 191p. (in Japanese).