Nuclear waste disposal, reprocessing, partitioning and transmutation in Japan

Satoru Tanaka*

This paper reviews recent R&D activities in Japan about nuclear waste disposal, reprocessing, and partitioning and transmutation.

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1 Nuclear Waste Disposal

Basic policy in Japan for nuclear fuel cycle is to reprocess the irradiated fuel and to utilize the recovered plutonium in Pu-thermal (mixed oxide fuel (UO_2-PuO_2) utilization in thermal reactor) and in future in fast breeder reactor. Radioactive wastes generated from the reactor operation and the fuel cycle can be grouped into several categories: low-level wastes from nuclear reactor operation, low-level wastes containing activated products from used control rods and decommissioned reactor, uranium waste from the fuel manufacturing company, TRU (transuranium) bearing waste from the reprocessing plant and the MOX fabrication plant, and high level waste from the reprocessing plant. In addition, radioactive wastes from research activities in institutions and universities should be considered.

Among these wastes, disposal of the homogeneous-type low-level waste from nuclear power operation is currently conducted in a shallow land (several meters depth) at Rokkasho-mura, which is located in the northern part of Honshu Island. Licensing process for the non-homogeneous low-level waste from the nuclear power station has been completed and the disposal will be started in a few years.

In the Atomic Energy Commission, basic strategies for waste processing and disposal have been discussed. Basic idea for disposing wastes containing activated products (high β and γ waste) is to be disposed in a shallow land (50-100 meters depth). Discussion about the strategy for TRU waste has been completed recently. Part of the TRU waste, which could not be disposed in a shallow land, should be disposed in a deep underground (geologic disposal). High level waste is the most important one. Returned high level waste from oversea reprocessing plants in Europe are also included. The most probable idea for this is to dispose it in deep underground, several hundreds meters depth, after solidification in glass waste form. The schedule for the high level waste disposal is as follows: Implementing organization, which is the responsible organization of the waste disposal, will be founded in 2000. Then this organization will select potential sites for disposal. The Government will approve the selection of the potential sites. After the selection of potential sites, preliminary geological investigations will be conducted. Based on the results, candidate site(s) will be selected by the organization around 2010. The Government will again endorse the selection. After the selection of the candidate site, more detailed geological investigation, or site characterization, will be conducted together with data acquisition for the safety evaluation and verification of the disposing technology. When a site is considered suitable for hosting a repository, the implementing organization will identify the site as the repository site around 2020 with the approval by the Government. After the safety evaluation by the Government, the construction of the repository will be started around 2025 and the disposal will start around 2030s to the beginning of 2040s. Consideration about the disposal of the uranium waste, which is the remaining waste type to be discussed in the Atomic Energy Commission, has started in March 2000. Key points in uranium waste disposal are dose criterion compared with natural background, accumulation of daughter radionuclides, and rational scenario for evaluating migration and exposure to mankind.

In the Nuclear Safety Commission, basic principal for ensuring safety and criteria for safety evaluation are being discussed. Current subject is to determine the safety principle for the high-level waste disposal. The key points are the responsibility of the electricity generating companies, criteria for long-term safety evaluation (dose and/or risk), and monitoring after disposal.

Researches and developments for radioactive waste disposal are being conducted in institutes, universities and private companies. Many of them are related to high-level waste, TRU waste or uranium waste.

Japan Nuclear Cycle Development Institute (JNC) is the responsible institute for R&D in high level waste. Here in JNC, many kinds of researches including geologic study, repository technology and data acquisitions for performance assessment are being conducted.

At Japan Atomic Energy Research Institute (JAERI), studies on methodology of safety evaluation and on mechanism elucidation of fundamental processes such as sorption and mineralization are being conducted together with environmental science and technology development for RI wastes from institutions.

In universities, many kinds of fundamental researches are being conducted ranging from environmental chemistry,

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Nuclear waste disposal, reprocessing, partitioning and transmutation in Japan, by Satoru Tanaka (e-mail chitanak@q.t.u-tokyo.ac.jp)
＊Department of Quantum Engineering and Systems Science,
The University of Tokyo 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, Japan

separation chemistry, and fundamental researches on sorption, actinide solution chemistry and solid chemistry of the waste form. Examples of the current R&D topics related to waste disposal are, (i) Chemistry, long-term stability, and nuclides sorption on cement, (ii) Elucidation of the sorption mechanism, (iii) Colloid generation and migration, (iv) Modeling of ground water flow, (v) Introduction of the idea of risk, (vi) solid chemistry of the actinides, (vii) Interaction with organic matters in the ground water, and (viii) Application of the quantum chemical calculation.

In private companies, more development-oriented works are being conducted with the sponsorship from the utility companies or the Government.

Many kinds of collaboration schemes exist among these institutions and universities. One of them is University-JAERI Collaboration Project for Actinides Chemistry and Engineering. At present, JNC and JAERI belong to Science and Technology Agency (STA), while universities to Ministry of Education (MOE). Ministry of International Trade and Industry (MITI) influences companies. In 2001, reforming of Government structures will be conducted. Then MOE and STA will be combined and more responsibility by the Nuclear Safety Commission is expected. At this time, reorganization of the R&D for waste disposal will also be made.

2 Reprocessing

The reprocessing plant at JNC-Tokai has a capacity of 210 ton/year. This reprocessing plant has been operated more than 20 years. TheTokai plant has a mission of research and development. At present, Rokkasho Reprocessing Plant is under construction by Japan Nuclear Fuel Ltd. (JNFL), which is a company for key parts of the nuclear fuel cycle: uranium enrichment, reprocessing and low-level waste disposal. This company was founded by the investment from the utility companies.

At present, oversea reprocessing is conducted. Irradiated fuels from power stations are transported to France or England for reprocessing and then separated uranium, plutonium and wastes are returned to Japan.

As the reprocessing and fast breeder reactor is the basic strategy in Japan, R&D activities for reprocessing irradiated fuel from fast breeder reactor has been conducted in JNC mainly based on PUREX method. In addition to this, many fundamental researches for innovative processing or separation are being conducted at universities JNC and Central Research Institute of Electric Power Industry (CRIEPI): Electrometallurgical method for metal fuel (at CRIEPI), advanced PUREX and TRUEX using TBP and CMPO (at JNC), and advanced PUREX using TBP+DIDPA (at JAERI), and fundamental researches such as crystallization and extraction using supercritical fluid at universities.

3 Partitioning and Transmutation

Separation of minor actinides and long-lived fission products such as Am, Np, I and Tc, and subsequent transmutation by a reactor or an accelerator-driven system are being studied as fundamental R&D in JAERI, JNC, CRIEPI and in a few universities. Atomic Energy Commission has recently reviewed partitioning and transmutation researches. The major conclusion is that the current level is the fundamental research level and that further research will be required to select the process, which is worth proceeding to the next research level considering total safety and cost. Partitioning and transmutation methods which are studied by these institutions are (1) four group separation using DIDPA extraction, precipitation of Tc, Cs and separation of Sr by ion exchanger, combining with a burning fast reactor or an accelerator driven sub-critical reactor at JAERI, (2) Separation by advanced PUREX and advanced TRUEX methods followed by transmutation in fast reactor at JNC, and (3) Separation by electrometallurgical method, reduced extraction using KCl-LiCl, combined with a fast breeder reactor using metal fuel at CRIEPI.

4 Conclusions

Reprocessing and MOX utilization in Pu-thermal or in fast breeder reactor is the basic concept in Japan. Geologic disposal is considered for high level waste after vitrification. Schedule for disposing high level waste has been decided and necessary action has started. Fundamental studies for waste disposal are being conducted in universities and at JAERI while more mission-oriented studies in JNC. Reprocessing plant with the capacity of 800 t/y is being constructed. Innovative reprocessing methods is being studied mainly at universities aiming at new processes with higher safety and lower cost. Partitioning and transmutation studies are the fundamental research level. Further studies are required for the next decision.