The Analysis of the Conversion Time of Process Material Diverted from Different Spent Fuel Recycle Facilities

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1. Introduction

Advanced reprocessing technologies are being developed in different countries aiming at reducing the volume of spent fuel to be disposed of, increasing the utility of natural uranium, enhancing the proliferation resistance, and reducing the toxicity of HLW to be disposed of. However, many nonproliferation experts are concerned about lack of timely warning for any possible diversion from those facilities. In this regard, this study tries to estimate and compare the conversion time between different advanced nuclear fuel cycle facilities. The conversion time used in this study is the time to convert diverted material into plutonium metal. Since the exact conversion time is very difficult to determine, the number of process steps for the conversion is compared and discussed in this study.

A total of seven advanced technologies were studied: the conventional wet reprocessing (PUREX) technology, three additional wet reprocessing technologies and three dry processes. The additional wet reprocessing technologiesinclude COEX (co-extraction) process being developed by AREVA [1], UREX+ (uranium-extraction) by Argonne National Laboratory [2] and NEXT (New Extraction System for TRU Recovery) process in Japan [3]. The dry processes include pyroprocessing (hereafter called Metal Pyro) being developed by KAERI (Korean Atomic Energy Research Institute), Dimitrovgrad Dry Process (DDP) for the production of oxide fuel from oxide spent fuel for use in fast reactors by RIAR [4] and the pyroprocessing (hereafter called Oxide Pyro) suggested by CRIEPI which employs the electrowinning of UO_2 prior to the electrochemical reduction to reduce the volume to be treated in the reduction process [5].

2. Conversion Process of Plutonium Metal

A simplified conversion process to recover plutonium metal from LWR spent fuel is selected. The conversion process steps were chosen from a number of alternatives that are reported in the literatures[5-7], and include disassembling, dissolvingoxide fuel, filtering, anion exchange, precipitating fluoride, calcination, and reduction.

The conversion time required to convert different forms of nuclear material into plutonium metal will depend on whether or not there is a clandestine facility and on a specific country's technology maturity as well. In this paper, it is assumed that the diversion happens in a country which is a contracting party to the IAEA additional protocol and has no clandestine enrichment and reprocessing facilities. First diverted materials favored by proliferators are selected to calculate the number of steps required for the conversion of diverted material to plutonium metal. The results for the process steps are described in Table 1, and indicate the pyroprocesses need more number of process steps than others. It means that the pyroprocess needs the longest conversion time relatively.

Table 1. Number of Process Steps for Different Materials

Processes	Diverted material favored by proliferators	No. of steps	Hot cell or Glove box
PUREX	PuO_2	1	GB
COEX	Uranyl nitrate + plutonium nitrate	6	GB
UREX+1	TRU in lactic solution	8	GB
NEXT	U/Pu/Np in solution	8	GB
Metal Pyro	TRU metal ingot	10	HC
DDP	UO_2+PuO_2	7	GB
Oxide Pyro	TRU metal ingot	10	HC

In the pyroprocessing(Metal Pyro), the transuranics (TRU) is normally obtained without separating pure plutonium products so that the separation of plutonium compounds from other actinide products and production of pure plutonium will require further purification and purification steps. In Russia DDP process, a mixture of $UO_2$and PuO_2 are obtained but require separation and purification which can be carried out in a glove box.

References

[1] O.H. Zabunoglu, L. Ozdemir, "Purex Co-processing of Spent LWR Fuels: Flow Sheet", Annals of Nuclear Energy, Vol. 32, p. 151-162 (2005)

[2] J. J. Laidler, "Advanced Spent Fuel Processing Technologies for the Global Nuclear Partnership", 9th IEM on Actinide and Fission Products Partitioning and Transmutation, Nimes, France(2006).

[3] T. Namba, H. Funasaka, Y. Nagaoki, "Prospects and Progress Status of the Advanced Fuel Cycle System", Atalante 2004 International Conference - Science for the Future Nuclear Fuel Cycles, Nimes, France, (2004).

[4] T. Kobayashi, S. Vavilov et al, "Plutonium Precipitation in the MOX Co-deposition Tests for the Oxide Electrowinning Process", J. of Nuclear. Science and Technology, Vol 42, No. 3, p. 295~300 (2005).

[5] Tadashi Inoue and Lothar Koch, "Development of Pyroprocessing and Its Future Direction", Nuclear Engineering and Technology, Vol.40, No.3, (2008)

[6] J.P. Hinton et. al., "Proliferation Vulnerability", Red Team Report, Sandia national Laboratory, SAND97-8203, (1996)

[7] M. Benedict, et. al., "Nuclear Chemical Engineering", McGraw-Hill Book Co., New York, (1981).

[8] O. J. Wick, "The Plutonium Handbook : A Guide to the Technology", American Nuclear Society, (1980).