http://dx.doi.org/10.5516/NET.06.2013.018

PRELIMINARY SAFETY STUDY OF ENGINEERING-SCALE PYROPROCESS FACILITY

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Received February 26, 2013
Accepted for Publication June 08, 2013

Pyroprocess technology has been considered as a fuel cycle option to solve the spent fuel accumulation problems in Korea. The Korea Atomic Energy Research Institute has been studying pyroprocess technology, and the conceptual design of an engineering-scale pyroprocess facility, called the Advanced Fuel Cycle (AFC) facility, has been performed on the basis of a 10tHM throughput per year. In this paper, the concept of the AFC facility was introduced, and its safety evaluations were performed. For the safety evaluations, anticipated accident events were selected, and environmental safety analyses were conducted for the safety of the public and workers. In addition, basic radiation shielding safety analyses and criticality safety analyses were conducted. These preliminary safety studies will be used to specify the concept of safety systems for pyroprocess facilities, and to establish safety design policies and advance more definite safety designs.

KEYWORDS : Pyroprocess, Pyroprocess Facility, Safety Evaluation, Hazard Analysis

1. INTRODUCTION

Spent fuel (SF) is inevitable byproduct of nuclear power generation. Spent fuel is highly radioactive waste, which contains uranium (U), transuranic elements (TRU), and fission products. The direct disposal and interim storage of spent fuel require wide and isolated areas, and thus it is not easy to find proper sites in Korea. Therefore, the development of an effective management or recycling technology of spent fuel is essential to enhance nonproliferation and environmental friendliness.

In Korea, pyroprocess technology has been considered as a fuel cycle option to solve spent fuel accumulation problems. Pyroprocessing is one of the key technologies used to recover actinide elements and long-lived fission products from the spent fuel in LiCl or LiCl-KCl molten salt by an electro-chemical reaction, and it is known that the technology is more advantageous than existing PUREX in terms of nonproliferation. KAERI (Korea Atomic Energy Research Institute) has been developing a pyroprocess technology for the recycling of spent fuels. PRIDE (PyRoprocess Integrated inactive DEmonstration facility) had been developed from 2007 to 2012 as a cold test facility to support integrated pyroprocessing and an equipment demonstration, which is essential to verify the pyroprocess technology [1, 2]. In PRIDE, depleted uranium is used for the process, and the maximum throughput is 10tHM per year. As the next stage of PRIDE, the design requirements of an engineering-scale demonstration facility are being developed, and a conceptual design of the facility is being performed. INL (Idaho National Laboratory) conducted a conceptual design of an AFCF (Advanced Fuel Cycle Facility) and accident analyses for AFCF to support the development of advanced technologies related to safeguards and security, instrumentation, process control and integration, and to provide data on the reliability and scale-up for full-scale separations and fuel fabrication facilities [3-6]. Also, JNC (Japan Nuclear Cycle Development Institute) have proposed the concept of safety systems in pyrochemical reprocessing systems and performed safety evaluations [7].

In this paper, the concept of the AFC (Advanced Fuel Cycle) facility was introduced, and its preliminary safety evaluations were performed. For the safety evaluations, anticipated events and accident events were selected, and environmental safety analyses were conducted for the safety of the public and workers. In addition, basic radiation shielding safety analyses and criticality safety analyses were conducted.

2. CONCEPTUAL DESIGN OF AFC FACILITY

The AFC facility for the pyroprocess demonstration consists of (a) processing equipment, (b) a hot cell facility, and a building structure to shield and isolate the process equipment, (c) h ot cell remote operation equipment for safety operation and maintenance, (d) an argon system to control the inert atmosphere of a process cell, (e) a utility supply facility, (f) material receipt and storage areas for spent fuel, (g) and a waste treatment area and a shipping facility.

The main process is composed of the disassembly and rod cutting of a spent fuel assembly, chopping and decladding, voloxidation, electrolytic-reduction, electro-refining, electro-winning, salt purification and recovery, waste form fabrication, off-gas treatment, and so on. Fig. 1 shows a flow diagram of the reference pyroprocess developed by KAERI.

2.1 Design Requirements

The AFC facility allows a maximum of 10tHM/yr of pressurized water reactor (PWR) fuel. The other top-tier requirements such as the operation rate, product and waste storage facility, reference spent fuel, facility design life, and so on were given in Table 1.

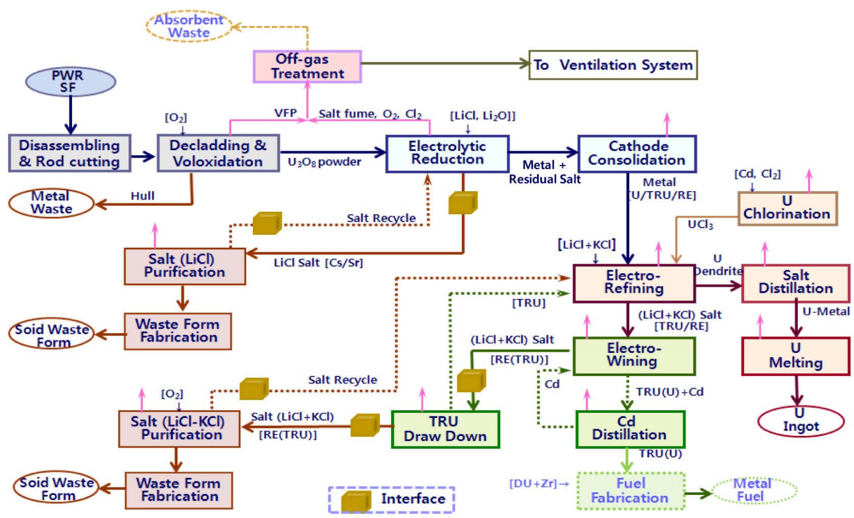

Fig. 1. Process Flow Diagram of the AFC Facility

Table 1. Top-tier Requirements of AFC Facility

Item	Requirements
Throughput	·10tHM/year
Reference Spent Fuel	·16×16 PWR Type, 4.5wt.% U-235 ·55,000 MWD/MTU, 10 Years Cooling
Availability	·70% (in Consideration of O&M Outage) ·200 Equivalent Full Operating Calendar Days
Design Life	·40 Years (Building and Cell Structure) ·20 Years (Equipment)
Input	·PWR Spent Fuels
Output	·U Metal Ingot as LLW, U-TRU-RE Metal Ingot for SFR Fuel ·Wastes (Ceramic, Metal, Virtrified Form)
Main function	·Temporary Material Storages (PWR Spent Fuel, Metal Ingot, Waste)
	·PWR Spent Fuel Disassembling, Rod Chopping
	·Decladding, Voloxidation, Electrolytic Reduction, Electro-Refining, Electro-winning, CD distillation, Cathode Processing ·U and TRU Metal Ingot Fabrication
	· Salt Waste Recycling, Waste Treatment, Off-gas Treatment