Pyroprocess Facilities for Used Nuclear Fuel Treatment

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1. Introduction

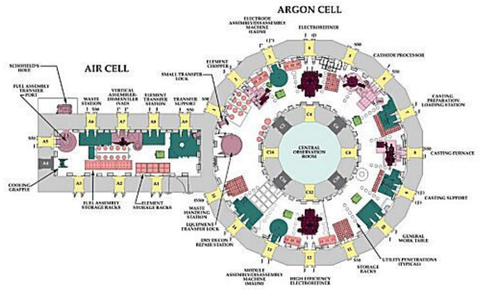
Used fuel, the essential by-product of electricity production by nuclear power reactors, is highly radioactive. For the disposal and re-use of the used fuel for the future expanded generation of nuclear power, a safe and non-proliferated treatment process should be developed. KAERI has focused on the project 'Development of Advanced Spent Fuel Management Technology', that is, the development and demonstration of a head-end part of pyroprocess.

In this paper, the status of several pyroprocess facilities developed and developing in the world were described and analyzed for the reference facilities of KAERI's future facility.

2. Pyroprocess Facilities

2.1. The FCF

The Fuel Conditioning Facility is located at the INL near Idaho Falls, Idaho in the USA. It was activated in 1963. FCF has two large, heavily shielded hot cells, one donut shaped with an argon atmosphere and the other is rectangular shaped with an air atmosphere. The argon cell is an annular, 16-sided polygon that is completely lined with a seal- welded steel liner, and in its center is a central observation room. The argon cell has 15 work stations around the outer periphery of the annulus and 4 inside the central observation room, each with a 5-ft thick window of oil-filled cerium-stabilized glass and a pair of remote manipulators. FCF is currently used for electrometallurgical treatment of EBR-II spent fuel. ANL proposes to continue operation of FCF and the electrometallurgical process to complete treatment of EBR-II spent fuel, with concurrent development and demonstration of advanced recycle technologies.

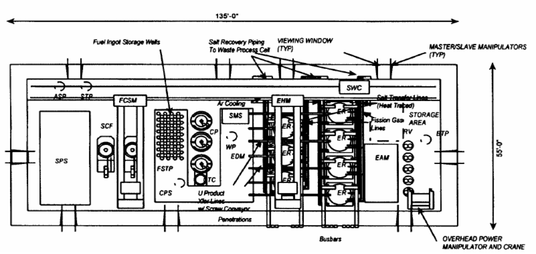


2.2. The SFRF

The Spent Fuel Recycle Facility is a commercial fuel recycle facility that provides for the processing of the LWR spent fuel, recycling the ALMR spent fuel, fabricating initial cores for plant startup fuel and initial reloads as well as fabricating replacement fuel assemblies during the 60 year life of the plant. High level radioactive waste from processing the LWR spent fuel and recycling ALMR spent fuel is conditioned within the facility and placed into a highly concentrated, leach-resistant form suitable for disposal in a waste repository. In order to reduce the volume of space needed in the repository, concentrated waste is initially placed in small containers that have decay heat values higher than could be accepted at a repository. Water cooled storage is provided for 10 years to allow cooling of the waste to acceptable levels. These small containers are then packaged into large containers for shipment to the repository. The SFRF also incorporates all the features of the Fuel Service Facility to support the refueling of the ALMR power plants on the site. The ALMR spent fuel is stored in an air cooled vault in the SFRF. The SFRF utilizes a pyroprocess.

The LWR spent oxide fuel is converted into ALMR metal fuel. The spent fuel from LWRs and ALMRs is disassembled and chopped by the use of remotely operated equipment. The chopped fuel is then transferred to a cell where different equipment is used to process either the LWR or

ALMR spent fuel to produce metal fuel for purification in the cathode processor.



2.3. The ARTF

The ANL has developed a full pyroprocess facility, the Advanced Recycle Treatment Facility, for several years. A conceptual design of the facility is being developed and refined using operational modeling techniques. Equipment is being designed to meet the mass-balance requirements associated with the flowsheet. Two of the main operations of the pyroprocess-based facility are direct electrolytic reduction of the spent oxide fuel to metal and electrorefining of this metal product to recover uranium.

2.4. The Pyro Facility for LWR MOX Fuel

In Japan, expected amount of MOX fuel burnt in 16 to 18 LWRs that will be planed to start in 2010 is 130 ton-heavy metal per year. The facility designs have been carried out for three throughput capacities, i.e. 32, 48 and 192 tons per year. It is assumed that these facilities would operate 200 days per year, with the non-operational days being used for maintenance. The reference spent MOX fuel chosen for reprocessing in these facilities is a pressurized-water-reactor MOX fuel having the average burnup of 48 GWd/t and cooling time of five years. The process includes 11 principal operations. Conceptual plant designs have been carried out step-by step; first for the 32- and 48-ton/year facilities; then for the largest 192-ton/year one. Arrangement of the main equipments and auxiliary equipments in main argon and air cells has been carried out; the layouts of main building were then designed based on engineering judgement. Construction cost of the facility was estimated using the numbers of the main and auxiliary equipments, the building volume, and their estimated unit costs. The estimated construction costs of the first units are 90, 96 and 215 billion yen for the 32-, 48- and 192-ton/year, respectively. Since capacity of waste treatment process is enough to treat waste from the 192-ton/year facility, the construction cost of waste treatment process and its temporary storage is the same value through the 32- to 192-ton/year facilities.

3. Discussion

KAERI has been developing the pyroprocess technology to reduce the volume of high level waste. Recently KAERI has developed the ACPF, which includes only a head-end part of pyroprocessing, an electroreduction process, and needs another facility for a rear part of pyropocessing, such as an electrorefining and cathode processing, etc. The above facilities in the USA and Japan described in this paper will be good reference facilities for future development of a full pyroprocess facility in the KAERI.

4. Conclusion

Through the analyses of pyroprocess facilities developing in the world, it is well recognized that the pyroprocess facility is very compact and has good benefits enough to develop for the future generation of nuclear power.

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