Review Study of Design and Development of Hot Cells

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1. Introduction

A conceptual design of a pilot-scale pyroprocessing facility (PSPF) was conducted by the Argon National Laboratory (ANL) in 2018 with throughputs of 100 ton/yr and 400 ton/yr [1,2]. In the summary report and literature, types and characteristics of processes are introduced with simplified layouts. In addition, capital costs and operating costs were presented for the two cases of throughputs, respectively. This conceptual design of PSPF has advantages of highly efficient processes with robotic cranes and electromechanical manipulators; and a duplicable unit layout of 100 ton/yr for a larger expansion in capacity.

In UK, UK Atomic Energy Authority's (UKAEA) Material Research Facility (MRF) operates several hot cells for preparation and examination of sample materials to be used in nuclear reactors. This facility has important roles to deal with materials of medium activities between universities (low activities) and National Nuclear Laboratory (NNL) (high activities) [3].

In this review study, layouts of the conceptual design of the facility and some hot cells are investigated for future works of a design and development of hot cells[4].

2. Results

2.1 Conceptual design of PSPF

• Conceptual design of the structure and process equipment for pyroprocessing of 100 tons of spent nuclear fuel in a light water reactor per year.
• The PSPF includes the separation process, waste process and interim storage for complete technology demonstration.
• Significant economies of scale are regarded to be achieved at the 400 ton/yr throughput rate.

2.2 Site plan of PSPF

The site covers about 52 acres(211,000 m^2) and divided into mostly three parts:

- Facilities and buildings inside the Protected Area
- Facilities and buildings outside the Protected Area
- Offsite location

Inside the Protected Area, there are Fuel Processing Facility and Generator Building.

On the other hand, there are eight parts outside the Protected area such as Protected Area Receiving Building; Waste Storage Facility; Laboratory and Operations Building; Maintenance and Mockup Building; Utility Building; Warehouse and Staging Building; Fire Station; Utility Electrical Substation.

Finally, offsite the location, there is an Emergency Operations Center.

2.3 Comparison of capital cost for 100 ton/yr and 400 ton/yr facility in PSPF

Capital cost estimates with and without contingency factor; and annual operating costs for 100 ton/yr and 400 ton/yr are listed in the table below, respectively. It is noted that, the land acquisition cost is not included.

Firstly, the cost estimation of 100 ton/yr were performed. And then, costs of 400 ton/yr were calculated by duplicating main process equipment with a factor of four while some equipment are with factors of three or two. Finally, the hot cell floor area of 400 ton/yr is 1.8 times larger than that of 100 ton/yr, showing advantages in economies of scale.

Table 1 Comparison of cost estimations of PSPF between 100 ton/yr and 400 ton/yr throughputs

	100 ton/yr	400 ton/yr	Etc.
Capital cos	324,308 $K (422 ₩B)	759,110 $K (987 ₩B)	Dollars in 2015, (Currency: 1,300 ₩/$)
Cost with contingency	397,614 $K (517 ₩B)	911,470 $K (1,185 ₩B)	
Annual operating cost	53,125 $K (69 ₩B)	90,000 $K (117 ₩B)	

2.4 Hot Cells in MRF

MRF has capabilities of the sample preparation, microstructural analysis, mechanical testing, and thermo-physical characteristics with several hot cells. The hot cells are operated by not only facility operators, but also each researcher who want to use it after finishing some education with a support team. Interestingly, Remote camera and robotic arms are

widely used for a sample treatment and experiment as shown in figures.

Fig. 1. Remote handling with a robotic arm at sample receiving cell.

Fig. 2. Remote handling with both a radiation shielding window and a digital monitor of remote camera.

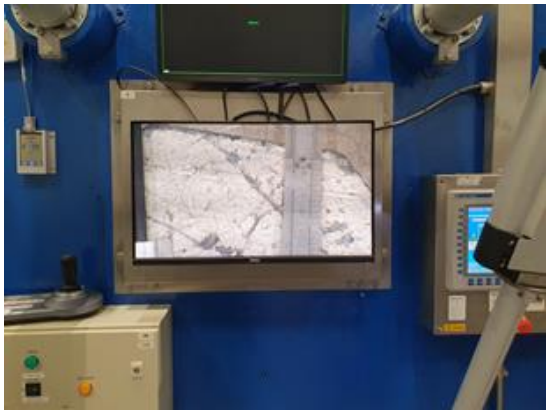

Fig. 3. Remote handling with only a digital monitor of remote camera.

3. Conclusions

The processes in PSPF have similarities with those in domestic pyroprocessing researches. Although those cost estimation values shown in the summary report provides relatively less detailed information, the cost estimations which were calculated from engineering analyses could be used for further designing works with significant implication and inspiration. Finally, the recent hot cells in overseas seem to have advantages of easy dealing and user-friendly functions. They could also be a good role model for further development of hot cells.

REFERENCES

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