Fuel Cycle Cost Modeling for the Generation IV SFR at the Pre-Conceptual Design Stage

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Abstract

Recently, several industrial countries using the fission energy have given attention to the Gen-IV SFR (sodium-cooled fast reactor) for achieving sustainable nuclear energy systems. In this context, an SFR is currently developed at the design concepts study stage in the Republic of Korea [Kim & Hahn 200909]. The sustainability of systems means economic, environment-friendly, proliferation-resistant, and safer systems. More specifically, this sustainability can be accomplished in terms of resource recycling and radioactive waste reduction.

In the present work, the objective of fuel cycle cost modeling is to identify the impact of various conceptual options as a cost reduction measure for the Gen-IV SFR at the design concepts study stage. It facilitates the selection of several reasonable fuel cycle pathways for the future Gen-IV SFR from an economic viewpoint.

Methods and Data

The methodology proposed is based on time-independent levelized fuel cycle cost modeling [EMWG 200709] at the cost estimating step. At the implementation step, a spreadsheet approach such as the G4-ECONS method [GIF 200803] is used. Time-independent cost modeling is especially useful for uncertain and rare unit costs data. The calculation algorithm is simplified using the (unit cost) $\otimes$ (annual mass flow) method. Here, the symbol $\otimes$ denotes a fuzzy multiplication operator.

The data for cost modeling consist of both the mass balance data and the unit cost data of fuel cycle stages. Of the two, the former is offered through a fuel cycle analysis team [Yoo 200910], and the latter is collected from available literature [Shropshire et al. 200901]. The unit cost ranges for each cost breakdown are used for taking the parametric uncertainty into account. Generally, the unit costs are seldom available for fuel cycle steps under consideration and are for services not available commercially.

For the first time, as shown in Fig.1, the process flow diagram for a closed fuel recycle is developed. This represents the simple linkage among reactor, front-end, and back-end stages. Based on the diagram, a mass flow diagram can be developed and used as an element for fuel cycle cost estimating. It is assumed that the SFR is serving as a break-even reactor instead of a transuranics burner (i.e. a waste burner for LWR spent nuclear fuels). Also, fuel cycles are assumed in equilibrium reloads on an annual basis.

References

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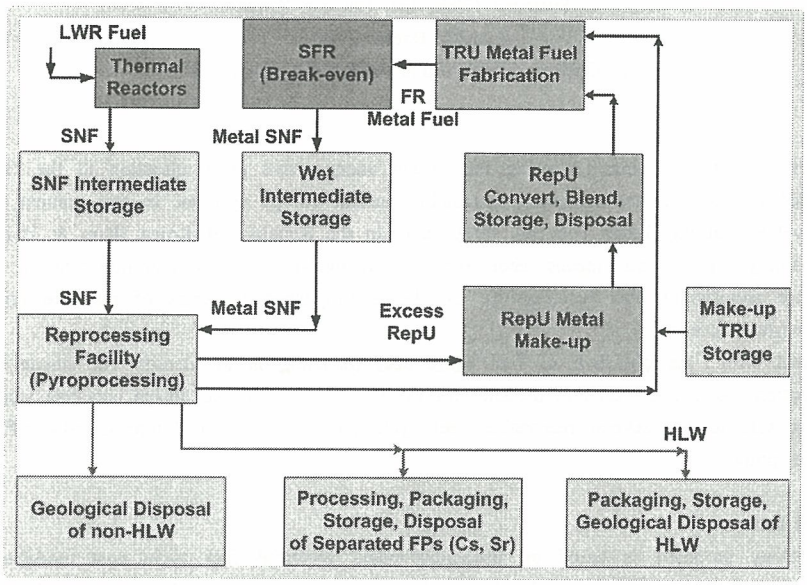

Figure 1. Process flow diagram for a closed fuel recycle