Task 8

Development of a Systems Engineering Model of the Chemical Separations Process

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GOAL AND BACKGROUND

Chemical separations processes and technologies are the corner stone of any strategy to reprocess or transmute used nuclear fuel. For the transmutation effort, the actinides, along with iodine and technetium, are the primary targets for partitioning. In the direct disposal waste management strategy currently envisioned, these elements are the primary components of the predicted risk to the public. Even if reprocessing the plutonium as reactor fuel does not come to pass, the removal of transuranics and long-lived fission products from discharged fuel dramatically decreases the toxic nature of the spent fuel significantly.

This research project proposes the development of a comprehensive systems engineering model of the chemical separations processes required for the transmutation program, with the goal of performing a system-wide evaluation and optimization of overall system deployment options. Systems analysis makes it possible to present decision-makers with concise evaluations of system options and their characteristic features. As the sophistication level of the systems engineering model is increased, it becomes possible to make relative comparisons of process options with regard to waste generation, proliferation resistance, throughput capabilities, facility requirements, and cost. Establishing confidence in the models gives the decision-making process greater objectivity and technical credibility.

OBJECTIVES

The first year of this research project was focused on studying and analyzing the process of developing a systems engineering model for the chemical separations processes. Specific research objectives include the following tasks:

- Developing a framework and environment for a systems engineering analysis of the chemical separations system for the program;
- Establishing a baseline systems engineering model from which modifications and improvements can be made; and,
- Refining the existing computer program that gives a detailed examination of the uranium extraction process, a critical component of the overall scheme.

Developing a systems engineering model involves establishing project goals and needs, defining all unit operations, and selecting the commercial software packages/ environments to be evaluated. A basic system model must first be developed. As part of this effort, the UNLV research team will refine Argonne National Laboratory's code, the Argonne Model for Universal Solvent Extraction, or AMUSE, which provides a baseline approach to the integrated analysis of the materials separations process. AMUSE analyzes the uranium extraction process along with other related solvent extraction processes. It defines many of the process streams that are integral to the systems engineering model. Improving and streamlining AMUSE involves reviewing/analyzing code structure, examining other possible implementations, defining first year software activities, developing a verification plan, and modifying/ improving the software. Combining the above tasks ensures that calculations made in AMUSE are accurately transferred to the overall systems model. Additional modules will be developed to model pyro-chemical process operations not treated by AMUSE.

CURRENT ACTIVITIES AND ACCOMPLISHMENTS

A number of software products are being evaluated for use in the systems engineering modeling project. These include iSIGHT, MATLAB, LBNL, SPARK (systems tool), ASPEN process modeling tool, Easy 5 (Boeing), Visual Basic/Visual C/C+ and others. Criteria for selecting one of these products includes the following: the ability to interact with a wide range of existing simulation tools written in a number of different languages and forms; the ability for the user to seek out and determine all input values and assumptions for each simulation package; the potential for integration over a disperse network system; the need for a drag and drop approach to adding additional components to the process; a simple process to transfer data between components; and, an ability to optimize individual processes or the complete system.

Preparation for system engineering development included specialized training. AMUSE code training was held in October for students, and a WebX training and informational conference for iSIGHT was held from 9-11:20 a.m. on December 14.

Once the software project has been selected, student training begins. The complete process will be defined within the selected software environment over the next several months. Attendance at the Argonne National Laboratory Transmuter Fuel Development Workshop made it clear that the product must be capable of analyzing a wide range of processes quickly and easily. Additionally, it is clear that developing a systems engineering model of the complete process proves quite valuable in assessing many of the proposed concepts.

The AMUSE code is currently being studied and analyzed. The interface of AMUSE has been designed using Visual Basic. The mass balance interface code has been designed and developed. The UREX visual Basic interface and design and implementation is still in progress. A software interlace model of the uranium extraction process is being written in visual basic.

To date, the system engineering model will be coupled with the graphical interface AMUSE code, MATLAB, and iSIGHT.

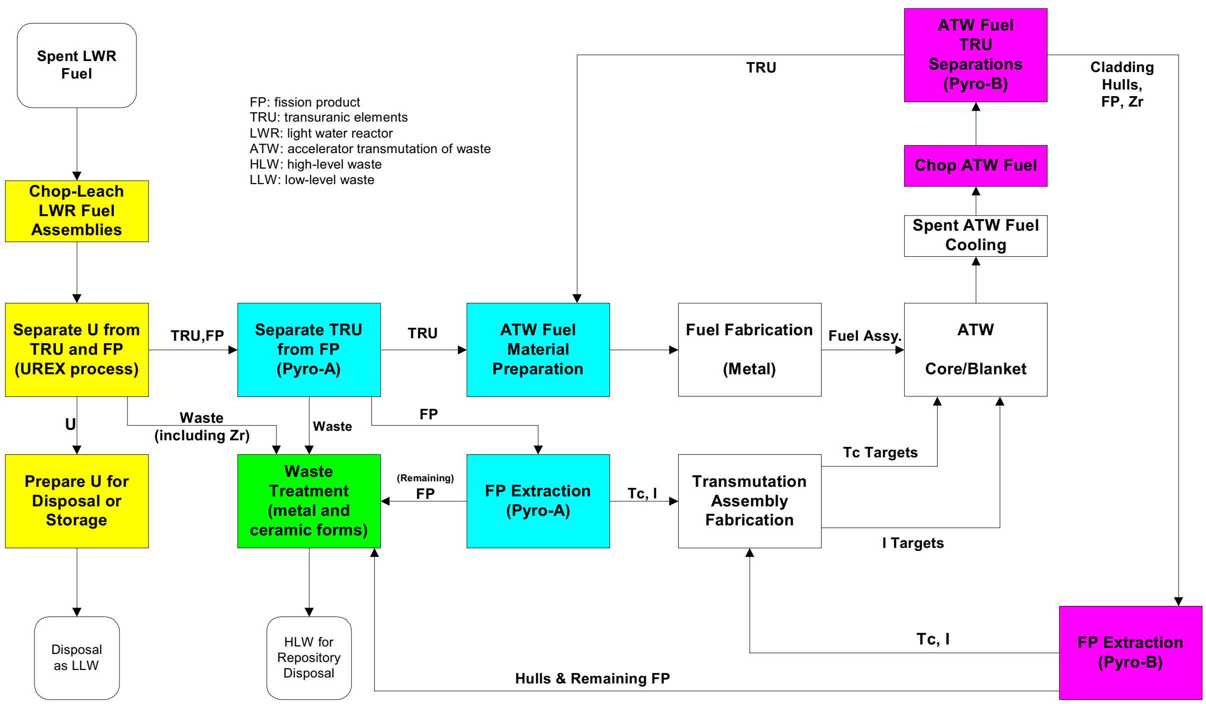
FUTURE PROGRESS AND GOALS

Work on revising the AMUSE code will continue. Since the AMUSE code analyzes chemical extraction processes, including uranium extraction, and defines many of the process streams integral to the systems engineering model, the calculations made in AMUSE need to be accurately transferred to the overall systems model. Additional modules will be created to expand the capabilities of the AMUSE code to address other solvent extraction processes, and new modules will be developed for analyzing the pyrochemical process operations. These modules will be refined as experiments are conducted.

This system model will then be used to analyze case studies and designs at ANL and UNLV to demonstrate the basic or advanced engineering system model. Additional analysis work conducted during this time will validate the engineering systems model efforts. It would also support the testing program associated with various models. Detailed modeling work will continue from year 1 to refine the existing models and to make detailed comparisons to the experimental test results. Finally, work will continue to optimize the AMUSE uranium extraction process.

HIGHLIGHTS

- Presentation of "Development of an Integrated System Engineering Interface for the Chemical Separations Process (AMUSE)" by Sridhar Munaga at the ANS Student Mini-Conference in Reno, Nevada, November 2001.
- Presentation of "Development of a Systems Engineering Model of the Chemical Separations Process" by Lijian Sun and Jianhong Li at the ANS Student Mini-Conference in Reno, Nevada, November 2001.
- Presentation of "Development of a Systems Engineering Model of the Chemical Separations Process" by Lijian Sun at the TRP Seminar at UNLV, Las Vegas, Nevada, April 2002.
- Conference paper entitled "Development of a Systems Engineering Model of the Chemical Separations Process" by L. Sun, J Li, Y. Chen, R Clarksean, D. Pepper, J. Laidler, and G. Vandergrift at the International Congress on Advanced Nuclear Power Plants/ANS, Hollywood, FL June 2002.



A block diagram of the current separations process as envisioned by Argonne National Laboratory researchers.

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