Task 8

Development of a Systems Engineering Model of the Chemical Separations Process

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BACKGROUND

The chemical processing of used nuclear fuel is an integral component of any strategy for the transmutation of nuclear waste. Due to the large volume of material that must be handled in this first step of the transmutation process, the efficiency of the separations process is a key factor in the potential economic viability of the transmutation strategies. The ability to optimize the chemical separation systems is vital to ensure the feasibility of the transmutation program.

Systems analysis, or total systems modeling, is one of the strongest tools available to researchers for understanding and optimizing complex systems such as chemical separations processes. Systems analyses permit researchers to present decision-makers concise evaluations of system options and their characteristic features. The primary goal of this project is to develop a systems model that can be used to parameterize and optimize chemical separations processes.

RESEARCH OBJECTIVES AND METHODS

The initial step of this project is designing a systems engineering model that involves defining project goals and needs, defining all unit operations (processes and waste streams), selecting modeling software packages, and developing a basic system model.

Argonne National Laboratory (ANL) has developed the Argonne Model for Universal Solvent Extraction (AMUSE) code for the analysis of the Uranium Extraction (UREX) and other related solvent extraction processes. While the AMUSE code defines many of the process streams that are integral to the systems engineering model, it requires better interaction to modularized and well-developed systems optimization packages.

Yitung Chen and Haritha Royyuru by their poster at the ANS Annual Meeting, San Diego, CA, June 2003.

This work includes reviewing and analyzing the AMUSE code structure, examining other possible implementations, defining software activities, developing a verification plan, and modifying and improving the software. This work also involves redefining the graphical user interface (GUI) to increase the utility of the AMUSE code suite as a stand-alone analytical package.

Developing a systems engineering model requires ongoing discussions with Argonne National Laboratory personnel to identify pertinent components of the chemical separations process. Each step requires model development to establish its significance with regards to the overall process. Comprehensive model development involves defining the inputs and outputs from individual models and establishing how each connects to the other within in the chemical separations process.

RESEARCH ACCOMPLISHMENTS

The framework and environment for a systems engineering model of the chemical separations system was developed during the first year. This model was established as the baseline model, which will be used as a reference for examining the impacts of any modifications or improvements. The model was implemented using a combination of MATLAB OPTIMIZATION toolbox and SIMULINK module from Mathworks.

A “drag and drop” type of graphical user interface was designed and developed by the UNLV team. The interface allows the user to quickly and easily define the UREX process and process inputs.

Object-oriented design is used to identify four major objects. First, the data input interface takes the user input from these blocks and creates an export file. Secondly, an export file serves as the input to the AMUSE code that performs all the chemical extraction calculations. The third component handles result file open and save. The fourth component acts as an optimization tool that continuously interacts with MATLAB commercial components until the optimization objectives are achieved. The AMUSE macros used were not modified by the UNLV’s researchers. Instead, the Microsoft Visual Basic (VB) interface was designed to call the AMUSE macros directly as part of the analysis of the system, thus preserving the original code developed and validated by the ANL team.

Further system enhancement allows the user to select various process types. An object-oriented programming concept is carefully implemented for higher flexibility on further process modification and module addition. An interface for conducting multiple runs has been created. The GUI includes a list of variables, a range for those variables, all of which provide an envelop of end results.

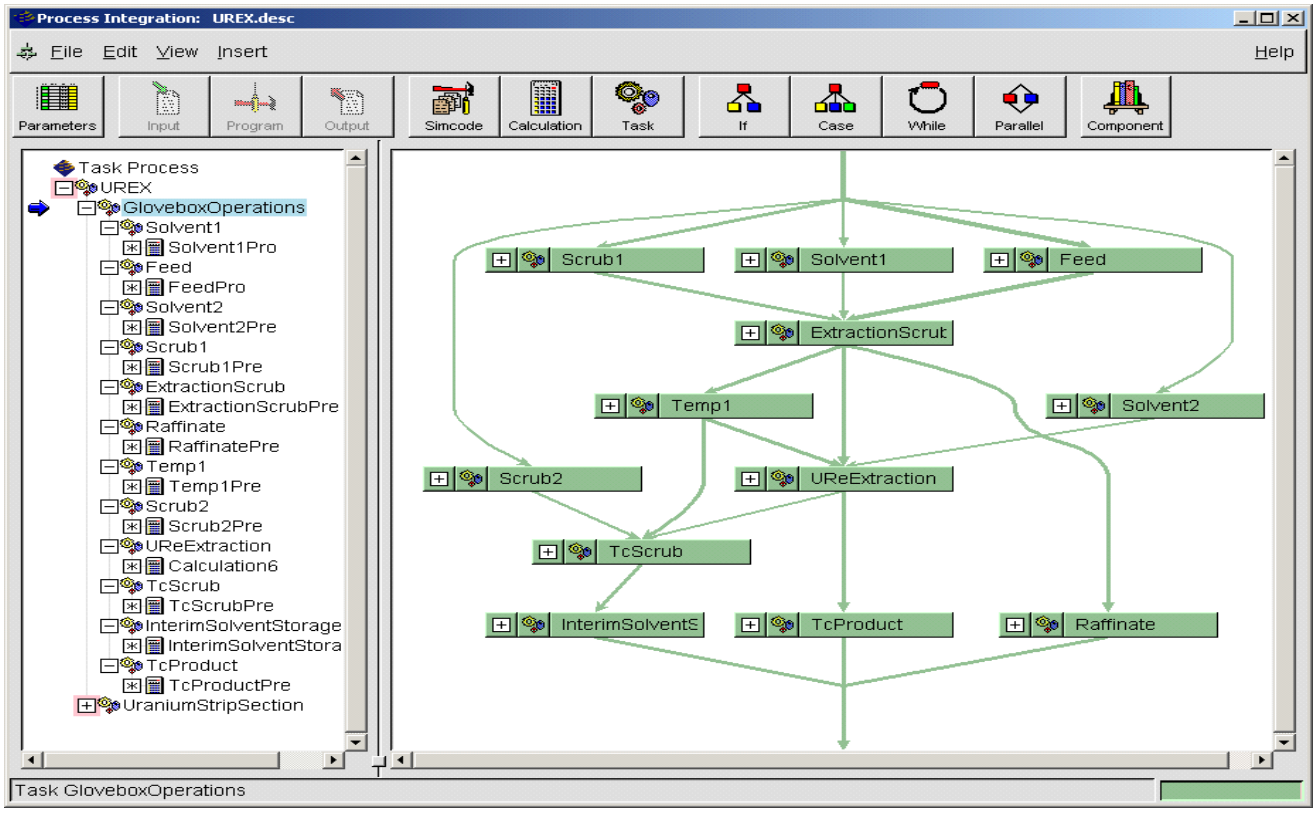
The researchers also accomplished the design and development of a mass balance interface code, as well as design and implementation of the UREX Visual Basic interface.

FUTURE WORK

The future work scope for the project includes increasing the sophistication of the systems engineering model. As optimization constraints are provided, relative comparisons of process options with regard to waste generation, proliferation resistance, throughput capabilities, facility requirements, and cost are possible. The final results from this project will provide engineers and scientists a user-friendly Window-based graphical user interface package. Increased confidence in the models and further refinements render greater objectivity and technical credibility to the decision-making process.

HIGHLIGHTS

- "Development of a Systems Engineering Model of the Engineering Chemical Separations Process" presented at the International Congress on Advanced Nuclear Power Plants, Hollywood, FL, June 9-13, 2002.
- "Development of a Systems Engineering Model of the Chemical Separations Process" presented at the AFCI Semi-Annual Review Meeting, Albuquerque, NM, January 22-24, 2003.
- "Development of an Optimization Systems Engineering Model for Spent Fuel Extraction Process" presented at the ANS Student Conference, Berkeley, CA, April 2-6, 2003.
- "Development of Systems Engineering Model for Spent Fuel Extraction Process" presented at the ANS Annual Meeting, San Diego, CA, June 1-5, 2003.



Example of a graphical user interface for one of the separations processes.

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