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FCFPYRO Simulation of the First Year FCF Hot Operation Plan

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Introduction

In order to track isotopic mass flows in the Fuel Conditioning Facility (FCF), both partition of nuclides in **space** and radioactive decay in **time** need to be considered. A simulation code package called FCFPYRO has been developed for such a task. It is capable of selecting specific EBR-II subassemblies from the Physics Analysis Data Base (PADB)[1], then going through the chopper model and the process flowsheet according to user specified process parameters, and finally producing results for the pyroprocess products and waste streams. All of the anticipated processes in the first year FCF hot operation plan can be simulated using one or combination of several process modules in this code package. After several iterations of selecting appropriate process modules and fine-tuning related process parameters, we have successfully completed a simulation study for the first year FCF hot operation plan.

FCFPYRO Simulation Code Package

The FCFPYRO code package consists of independent calculational modules that can be put into three functional groups: **(i)** the basic PYRO code[2] which models the chemical element mass flows and phase compositions in the electrorefining process; **(ii)** the extension of the basic PYRO code to track ~ 1200 isotopic species and their radioactive decays[3]; and **(iii)** the interface capability required by the Mass Tracking System (MTG)[4] for FCF. Specific computational modules are developed for various physical or chemical steps: such as dissolution, oxidation, electrotransport, reduction, distillation, melting, decay, or mechanical split and combine operations, etc. Interface files are used to pass information between modules. A driver program is constructed by the user to run certain computational modules according to process flowsheet and input process parameters. Once the required user inputs are prepared, a Unix based control script in the Sun workstations will automatically manage the code execution and data interface.

First Year FCF Hot Operation Plan

According to the current FCF hot operation plan, standard EBR-II spent binary driver fuel assemblies presently in the Hot Fuel Examination Facility (HFEF) will be processed first. In addition, loose binary pins and intact experimental fuel assemblies presently in HFEF will also be processed. In this way, fuel transfer from the Radioactive Scrap and Waste Facility (RSWF) to FCF will not be required initially. In this simulation study, we assume fourteen batches of EBR-II spent binary driver fuels (equivalent to ~ 60 assemblies) are processed during the first year. Different methods for fuel dissolution and conditions for electrotransport of actinides to solid cathodes are simulated. The effect of noble metal retention screen is also simulated. The screen is designed to hold ~ 75 weight % of noble metal fission products from dropping to the pool. Using the FCF-PYRO code package, we can compare simulation results and assess the merits of various process conditions and operational strategies.

Simulation Results

The FCFPYRO code package tracks isotopic mass flow in eight partition regions: anode basket, cadmium pool, electrolyte salt, solid cathode, liquid cathode, metal waste, salt waste, and argon cell. Batchwise properties are edited at various (nuclide, element, group) levels of details for each partition region, including: mass, radioactivity, total heat, gamma heat, photon spectrum, and neutron sources. In this paper we will report the heat load to the electrorefiner (ER) as a demonstration of the capability of the FCFPYRO code package.

The heat from spent fuels consists of beta and gamma radiations. The effect of beta radiation is localized while that from gamma can reach much larger distance. Therefore, not only the spatial distribution of the heat source but also its form as beta and gamma are needed to fully address the heat removal issues. Fig. 1 shows the batchwise heat contents in the feedstock and the cumulative heat load to the electrorefiner. For most of the 14 batches, the feedstock heat content is < 150 watts; and the bulk (> 80%) is from beta radiations. The cumulative heat load to the electrorefiner should always be smaller than the cumulative sum of the input feedstocks due to the partition to waste streams and the "aging" (radioactive decays) of earlier batches. The cumulative heat load increases almost steadily to ~ 950 watts after processing 14 batches. This is well below the 6 kW design limit for the electrorefiner. Most (~ 90%) of this heat is beta radiation from the fission products (alkali, alkaline earth, and rare earth elements) in the electrolyte salt. The effect of using noble metal retention screen after batch 4 is evident in slowing down the rate of increase in the cumulative heat load to the electrorefiner.

Summary

A simulation study has been successfully completed according to the first year FCF operational plan for the treatment of EBR-II spent fuels. Material flow by nuclides for each processing step and radioactive decays during the process are considered. The FCFPYRO code package is a very useful tool to provide step-by-step information essential to the analysis of operational strategy, process chemistry, heat removal, criticality safety, and radiological health issues in FCF.

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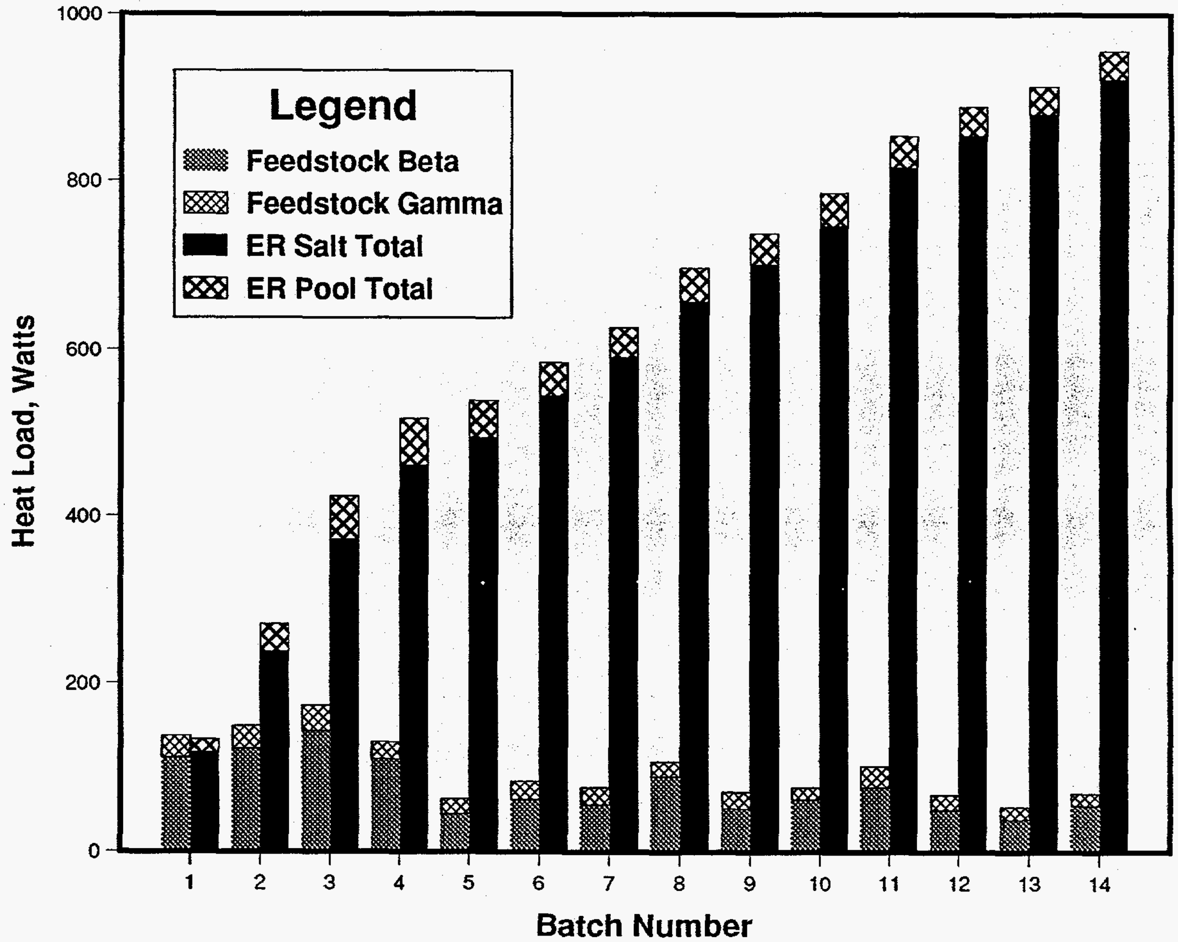

Fig. 1. Batchwise Heat Contents in the Feedstock and Cumulative Heat Load to the Electrorefiner