Numerical Analysis of Electrorefiner of Pyro-chemical Processing for PEACER

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A lead-bismuth cooled fast reactor, PEACER, is being developed for transmutation of long living radioactive waste from LWR spent fuel. Pyrochemical processing is utilized to separate uranium and transuranic (TRU) elements from the spent fuel and prepare PEACER fuel. Decontamination Factor (DF) is introduced to evaluate process performance. DF for a nuclide is defined as the ratio of total mass of nuclides into the process to the mass that escapes the process and get into the waste stream. DF of pyro-processing should be achieved above about 10^5 for actinides to meet the Intermediate Low Level Waste (ILLW) regulation. In addition, a minimum level of throughput should be met in order to balance materials flow from PEACER and LWR spent fuel. Flow-sheet of pyrochemical processing is conceived as a part of the entire transmutation system of PEACER including chopping, voloxidation, oxide reduction, electrorefining, electrowinning, reductive extraction and selective oxidation.

But it is difficult to achieve high DF value and throughput using present pyro-chemical process technique and design. Since design of pyrochemical processor should be optimized to achieve the desired DF, simulation model development for pyroprocess is one of essential approach for process design improvements. A method to analyze the performance of pyrochemical processing was contrived and the parametric study of electrorefining process was performed. The current limit and throughput of electrorefining process could be obtained from the calculation results of diffusion layer and deposition rates at cathode using hydrodynamic analysis code, ANSYS® CFX-10.0 and electrochemical reaction analysis model, REFIN.

Additional analysis of electrorefining process is needed due to variation of diffusion layer thickness with position, which leads the variation of the electrochemical reaction rate near the electrode surface. Thus a method, to consider the effect by variation of diffusion layer thickness, is developed. Effective current limit of electrorefiner, I_{eff} , which consider the effect of diffusion layer thickness variation, was calculated from the result. Deposition behavior at the cathode of electrorefiner can be divided into three stages by current limit for the thickest diffusion layer and I_{eff}. Results including benchmark with experimental result also will be presented applying the method. Discussion about the approach and analysis result of electrorefining process will be presented.