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INTRODUCTION

Pyrochemical processing plays an important role in the development of next generation nuclear reactors and closed nuclear fuel cycle technology. The Idaho National Laboratory (INL) has implemented a pyrochemical process for the treatment of sodium-bonded spent fuel from the Experimental Breeder Reactor-II (EBR-II). A successful demonstration of the technology was performed from 1996 to 1999 for the Department of Energy (DOE) [1]. Processing of the spent fuel and associated research and development activities have been integrated into DOE's Advanced Fuel Cycle Initiatives (AFCI) program since 2003. Electrorefining can be considered to be the signature or central technology for pyrochemical processing. In order to assess the efficiencies involved in the electrorefining process, an integrated electrorefining efficiency test was performed in the Mk-IV electrorefiner. This paper summarizes the observations and results obtained from the test.

EXPERIMENT AND RESULTS

The primary goal of the integrated processing efficiency test is to demonstrate the integrated actinide dissolution and recovery efficiencies typical for the fixed operating parameters that have been applied to Mk-IV electrorefiner (ER) and cathode processor (CP) to treat spent EBR-II driver fuel during the last three years. The findings are of importance for scaling-up the pyroprocess to recover and recycle valuable actinides from spent nuclear fuel.

The test was performed in the Mk-IV electrorefiner. The ER is located in the hot cell of the Fuel Conditioning Facility at the Materials and Fuels Complex. Descriptions of the major components of the ER and the process in general have been provided elsewhere [2]. Salt and cadmium levels were measured, and multiple samples were obtained prior to performing the integrated test to establish an ER baseline for assessing the test results.

The test consisted of four electrorefining batches of spent driver fuel with approximately 50 kg heavy metal. Typically, three to four ER runs are required to complete a batch. Fig. 1 shows pictures of the cathodes produced by three electrorefining runs during the second batch. The cathode No.3 in the figure has clearly different morphology than that of the first two. The cathodes produced by the other three batches have the similar morphology as those pictured. The first and second cathodes are ordinary uranium dendrite, and the third and fourth cathode show typically high Zr content morphology [3].

The end-point for each batch was determined by weighing each anode basket and assuring a net residue mass being equal or less than 3.0 kg. The 3.0 kg residue included any un-dissolved fuel constituents and adhering salt. Previous operating experience has shown that uranium dissolution in excess of 99.7 wt% was achieved when using this established end-point. Cladding hull samples were taken from each basket after it was removed from the ER. The actinide dissolution efficiency will be evaluated when the analytical results become available.

As a part of the integrated efficiency test, the cathodes produced by the ER runs were transferred to the CP to remove the adhering salt. To gain a better understanding of the materials transferred during different stages of the electrorefining, it was decided that only the first cathode produced in each ER batch were combined in the CP and casting furnace (CF) runs. The second and third cathodes from each ER batch were also segregated in this manner for processing at the CP and CF. The resulting pin samples have been taken from each CF ingot for chemical analysis.

Results from the CP runs have shown that the salt fractions in the first, second and third cathode products were 24.1, 28.7, and 43.8 wt%, respectively. It was expected that Zr would be electrochemically transferred in the latter stages of the electrorefining, such as the run No. 3 due to the depletion of uranium from the anode. It appeared that the increase of the Zr concentration in the cathode deposit altered the cathode morphology, and resulted in more salt cohering to it.

Condensate collected during the CP operations supporting the integrated efficiency test was returned to the ER in its entirety prior to final salt and cadmium sampling. Mass balance around the ER and CP during the integrated efficiency test, completeness of actinide dissolution, and actinide recovery efficiency will be reported in a separate paper after all the sample analysis results become available.

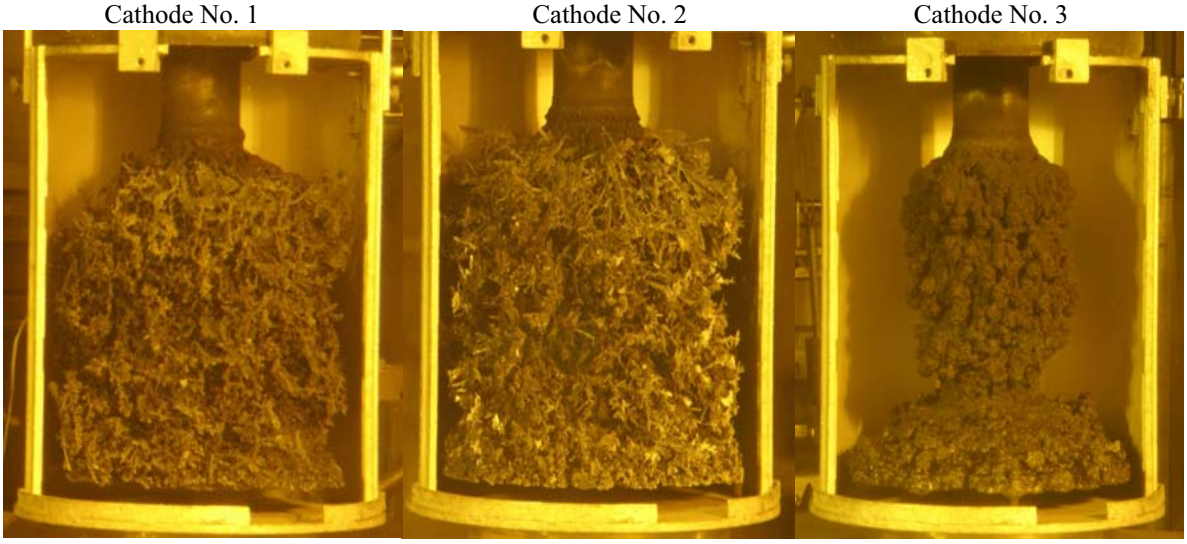

Fig.1 Three cathodes produced through electrorefining the second batch of spent EBR-II driver fuel

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