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Determining Bond Sodium in Plenum Region of Spent Driver Fuel

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INTRODUCTION

The Fuel Conditioning Facility (FCF) at the Idaho National Laboratory (INL) treats spent nuclear fuel using an electro-chemical process that separates the uranium from the fission products, sodium thermal bond, and cladding materials [REF 1]. Upon immersion into the ER electrolyte, the sodium used to thermally bond the fuel to the clad jacket chemically reacts with the UCl_3 in the electrolyte producing NaCl and uranium metal. The uranium in the spent fuel is separated from the cladding and fission products by taking advantage of the electro-chemical potential differences between uranium and the other fuel components. Assuming all the sodium in the thermal bond is converted to NaCl in the ER, the difference between the cumulative bond sodium mass in the fuel elements and the cumulative sodium mass found in the driver ER electrolyte inventory provides an upper mass limit for the sodium that migrated to the upper gas region, or plenum section, of the fuel element during irradiation in the reactor. The plenums are to be processed as metal waste via melting and metal consolidation operations. However, depending on the amount of sodium in the plenums, additional processing may be required to remove the sodium before metal waste processing.

DATA COLLECTION

In the FCF there are two choppers. The element chopper chops driver elements and the blanket chopper chops blanket pins. There are also two electrorefiners. The driver ER processes primarily driver elements and some blanket pins. The blanket ER presently only processes blanket pins. The focus in this paper is on the driver ER. Data analysis of the FCF Mass Tracking System database showed that of the 3,400 kg of uranium and 41.3 kg of sodium processed through FCF, 983 kg of uranium and 23.7 kg of sodium was segmented from driver elements and blanket pins for processing through the driver ER. Assuming that all of the sodium that enters the ER also accumulates in the ER, then the measurement of the sodium in the ER electrolyte provides a measure of how much sodium bond from the fuel elements reached the driver ER. The cumulative sodium mass of the ER electrolyte inventory includes electrolyte effluent streams that did not return to the ER inventory. Examples of such effluent streams are electrolyte adhering on fuel baskets and cathode products, electrolyte removed from the driver ER for lab-scale experiments, etc.

RESULTS

Figure 1 shows the cumulative sodium in spent fuel and the sodium inventory measured in the ER electrolyte as a function of uranium mass processed through the driver ER.

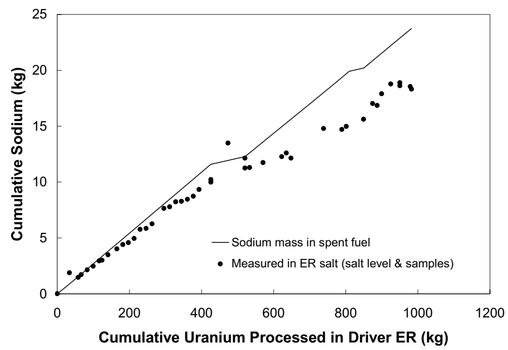

Figure 1. Sodium Mass in Spent Fuel and Sodium Mass in ER Electrolyte

The amount of sodium in the electrolyte diverged from the amount of sodium in the fuel as more uranium was processed. On average, for every 1 kg of uranium processed, approximately 0.0053 kg of sodium did not enter the ER. In other words, approximately 22% of the bond sodium in the fuel did not report to the ER. This absent sodium was either in the plenum region of the spent fuel or was lost to the chopper inventory during element chopping. This gives the upper limit of the amount of sodium to deal with during metal waste processing.

CONCLUSIONS

By measuring the amount of sodium that accumulated in the electrolyte and assuming all the sodium in spent fuel reports to the electrolyte, one can determine the upper limit of sodium that could possibly end up in the metal waste stream. Based on the data collected after nearly twelve years of processing spent fuel at the driver ER in FCF, it has been determined that about 22% of the sodium in the driver fuel elements was not measured in the ER electrolyte and the ER electrolyte effluent streams. Future work will study the element chopper in detail to determine the location of this sodium.

REFERENCES

[1] J. P. Ackerman, "Chemical Basis for Pyrochemical Reprocessing of Nuclear Fuel", Ind. Eng. Chem. Res., Vol. 30, No. 1, 1991