Contribution ID: **906** Type: **Verbal**

Characterisation of Contaminated Stainless Steel from Acidic Reprocessing Environments

Thursday, 19 May 2022 16:40 (20 minutes)

The Thermal Oxide Reprocessing Plant (THORP) at Sellafield has reached its end-of-life and is about to be decommissioned. One of the first steps to reducing the hazards associated with the plant is Post-Operational Clean Out (POCO). As part of this process, a large amount of radioactive metallic waste is required to be managed through the waste hierarchy, with one of the key stages being decontamination.

One of the major components of this metallic waste is stainless steel. Work has been ongoing to identify the extent, nature and depth of contamination of stainless steel by various problematic radioisotopes present in hazardous aqueous waste streams. Developing our understanding of the mechanisms by which contaminants interact with stainless steel surfaces is key to the development of tailored decontamination approaches, which can address challenges associated with waste management, such as volume minimisation. Cost savings upwards of £500 million are possible through re-categorisation of the UK's current stainless steel waste inventory.

Simulation of contamination is an important avenue of investigation as analyses of plant samples pose a number of challenges. Our work has targeted conditions similar to those observed in a number of processes at THORP, which involve dissolution of components in nitric acid. Work has explored how concentrated nitric acid at elevated temperatures affects contamination of stainless steel by high yield fission products over extended time periods.

Solution analysis, as well as characterisation of stainless steel coupons has been undertaken. Uptake kinetics are fast, with equilibrium being achieved within two weeks. Effects of corrosion are significant, as observed through Scanning Electron Microscopy, with significant levels of intergranular corrosion and grain dropping. Non-destructive surface-based analysis techniques, such as Laser Induced Breakdown Spectroscopy (LIBS) and X-ray Photoelectron Spectroscopy (XPS) have been employed to identify the presence of contamination in the very thin oxide layers (< 10 nm), as well as potential binding mechanisms. Depth profiling through Glow Discharge Optical Emission Spectroscopy (GD-OES) has identified the presence of contaminants in the bulk substrate, due to diffusion down corroded grain boundaries. With this knowledge, decontamination strategies tailored to minimise both primary and secondary waste streams, subsequently minimising the associated economic and environmental burdens.

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Session Classification: Nuclear Fuel Cycle

Track Classification: Chemistry of Nuclear Fuel Cycle, Radiochemical Problems in Nuclear Waste Management