framatome

Level III BWR Fuel CRUD Risk Assessment Tools/Methodology

Framatome's assessment tools help utilities optimize core design and coolant chemistry while managing the risk of crud deposition on fuel.

Challenge

Determining the level of risk for crud deposition in BWR fuel assemblies is a regular assessment need to ensure fuel reliability. Utilities seek innovative ways to determine how crud is deposited over time and the associated fuel cladding corrosion risk. These methods must be flexible for a variety of BWR fuels, reliable, and timely.

Solution

The Framatome level III fuel crud risk assessment process employs two coupled tools. The first tool is a fuel crud deposition model named FDIC (Fuel Deposit Interfaced with plant Chemistry) to assess/model crud deposition on BWR fuel assemblies over their lifespan [1]. In addition to the FDIC model, another tool, PEZOG (platinum -enhanced zirconium oxide growth), is used for plants using On-Line Noble Metal Chemistry (OLNC) technology to address the PEZOG [2]. Detrimental effects of species deposited in crud are evaluated relative to enhanced corrosion and/or detrimental thermal effects (e.g. hot spots). The FDIC-PEZOG-Corrosion tool results in a novel approach to modeling the total impact of crud deposition on fuel reliability.

The Framatome BWR Crud Assessment predicts how crud is deposited on fuel cladding surfaces as well as the crud composition. The models incorporate a realistic distribution of steam chimneys and capillaries, based on currently available plant data, which form a sponge-like crud layer and define the thermal properties of the deposit. The chemistry engine within the tools is powered by OLI's Analyzer* software, a commercially available computer software package (and associated databases) employing a predictive thermodynamic framework for calculating the physical and chemical properties of multi-phase, aqueous-based systems. An overview of the approach used by the Framatome BWR Crud Model is available in a number of industry presentations [3] [4].

Customer benefits

- Optimize chemistry and core design for improved economics
- Avoid costly corrosion-related fuel failures
- Minimize plant dose rates while preserving fuel performance

Your performance
is **our** everyday **commitment**

The Framatome tools predict the fuel cladding oxide growth (corrosion), the deposited crud thickness, and the platinum deposited in the crud, as the fuel is maintained in the core (over the life of the fuel). The tools have been benchmarked using industry surveillance data; for example, the results from both fuel surveillance/crud sampling and analysis campaigns before and after the application of OLNC [5]. Laboratory crud evaluations provided physical benchmarking data for direct comparison with the predictions made by the Framatome Risk Assessment tools.

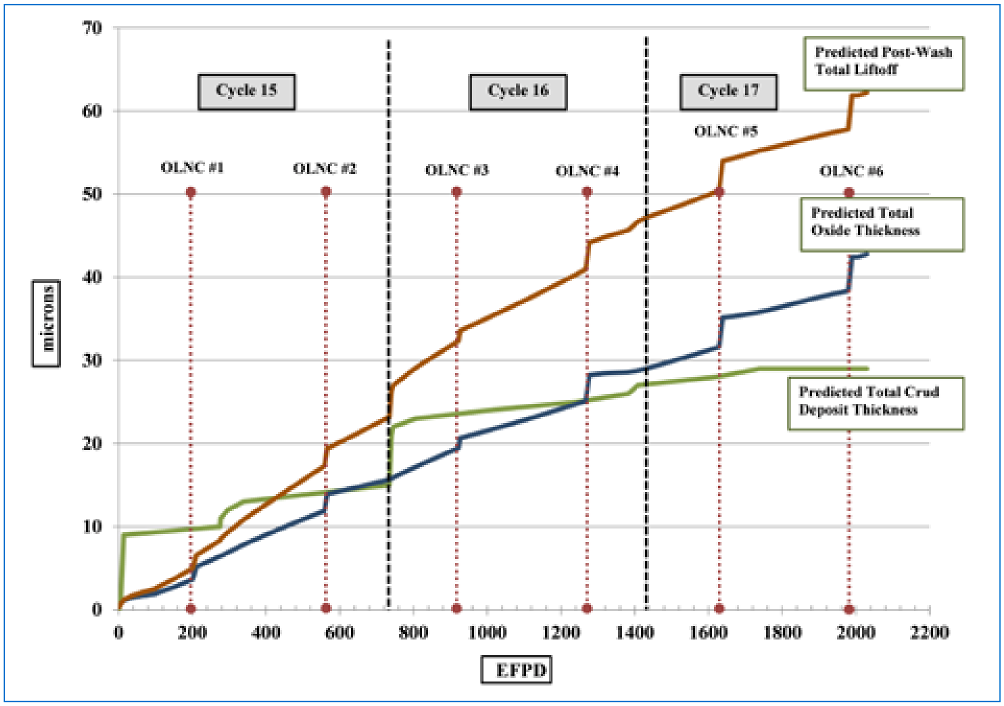

Figure 1: Predicted post-washing total liftoff at limiting core location

Features

- Tools used for the analysis have large flexibility, accommodating any type of BWR Fuel with all chemistry regimens (NWC, HWC, NMCA, and OLNC)
- The tools work on a PC platform
- The whole analysis requires two weeks for delivery of preliminary results, after the chemistry and T/H files are formatted for the application

In Figure 1, the effect of increased oxide on the total liftoff is seen growing after each OLNC application for a given U.S. BWR plant. Also the effect of redistribution of crud is seen to be highest at the beginning of the first cycle of fuel operation, then decreasing at the beginning of the second and third fuel cycle. The combined effect of crud redistribution and oxide increase after each OLNC application is seen increasing in amplitude towards the end of the life of fuel.

References:

1) U.S. Patent Application No. 14/041,806, Unpublished (filing date Sep. 20, 2013) (Mihai G. M. Pop, applicant).

2) U.S. Patent Application No. 13/751,956, Unpublished (filing date Jan. 28, 2013) (Carola A. Gregorich, applicant).

3) M. Pop, L. Lamanna, M. Bell, J. Riddle, and A. Hoornik, “Use of the AREVA BWR Crud Model to Study High Zinc Operation at a U.S. Plant”, 15th International Conference on Environmental Degradation of Materials in Nuclear Power System, Colorado Springs, CO. 7-10 August 2011.

4) T. Keheley, M. Pop, and G. Bhandari, “AREVA NP Approach to Fuel Reliability Using a Combination CFD Fuel Deposition Modeling,” Fontevraud 7, Avignon France, 26-30 September 2010.

5) Mike G. Pop, Larry S. Lamanna, Al Hoornik, Gregory C. Storey, James F. Lemons “Benchmarking of AREVA BWR FDIC-PEZOG Model against First BFE3 Cycle 15 Application of On-Line NobleChem™ Results” Fontevraud 8 – Avignon, France – 14-18 September 2014.

* OLI Systems Inc. Morris Plaines, New Jersey

Contact: chemistry-services@framatome.com
www.framatome.com

framatome