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Advanced technology fuels material property models implementation in the TRANSURANUS platform

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This poster presents the extension of TRANSURANUS to account for new fuel features, following the VVER-440 fuel rod design change methodology developed in the **ESSANUF** project, and highlights the implementation of material property models for advanced technology fuels (ATFs) into the code, including contributions from the **R2CA**, **McSAFER**, and **APIS** projects. The poster also provides an outlook on the optimization of material property models through an advanced calibration methodology.

1. Fuel rod design change methodology for VVER-440

The EU-funded ESSANUF project aims to enhance the security of nuclear fuel supply by developing an alternative fuel design and licensing methodologies for the VVER-440 reactors in the EU and neighbouring countries. New models for inner cladding oxidation and hydrogen uptake were developed and implemented in TRANSURANUS. The code's probabilistic analysis capabilities were also extended to include fission gas behaviour and cladding oxidation rates.

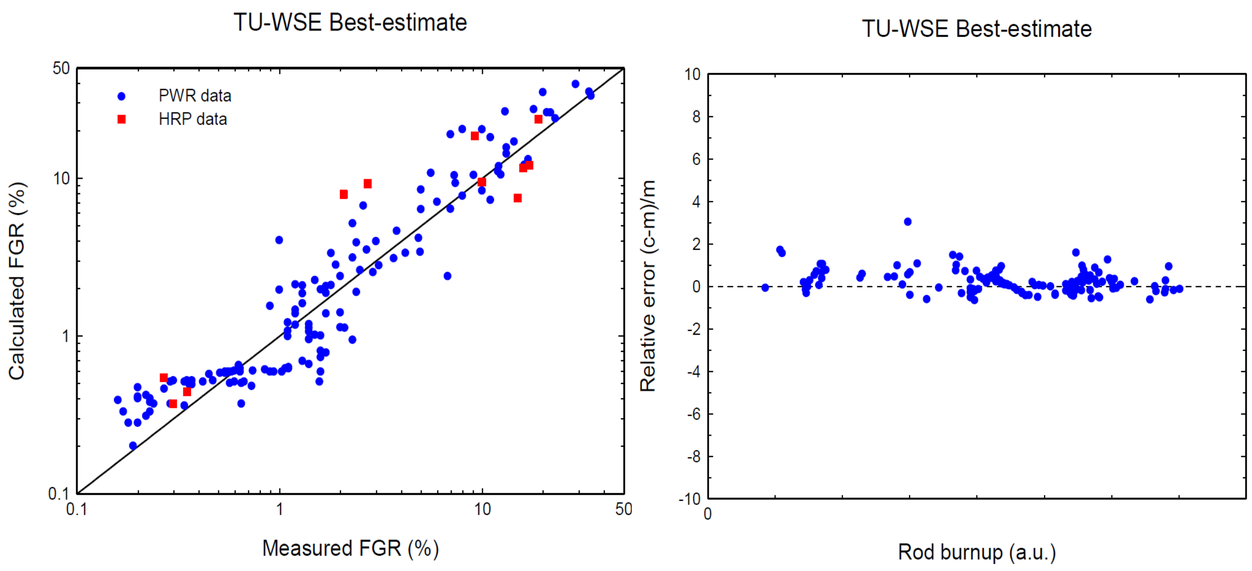

Figure 1. Comparison of measured and calculated FGR data (left) and relative error of FGR prediction as a function of burnup (right).

2. Implementation of material properties for ATF

In the frame of the McSAFER and R2CA projects, additional material properties were implemented for FeCrAl, Cr-doped UO_2 and U_3Si_2. A NuScale core, loaded with the U_3Si_2-FeCrAl fuel system, was simulated by means of a coupled code system involving TRANSURANUS. In the APIS project, new diffusion coefficient and creep models for Cr-doped UO_2 were implemented. The extended code was then applied to simulate the AGR-like fluoride-cooled high temperature reactor (FHR) during normal and off-normal operation.

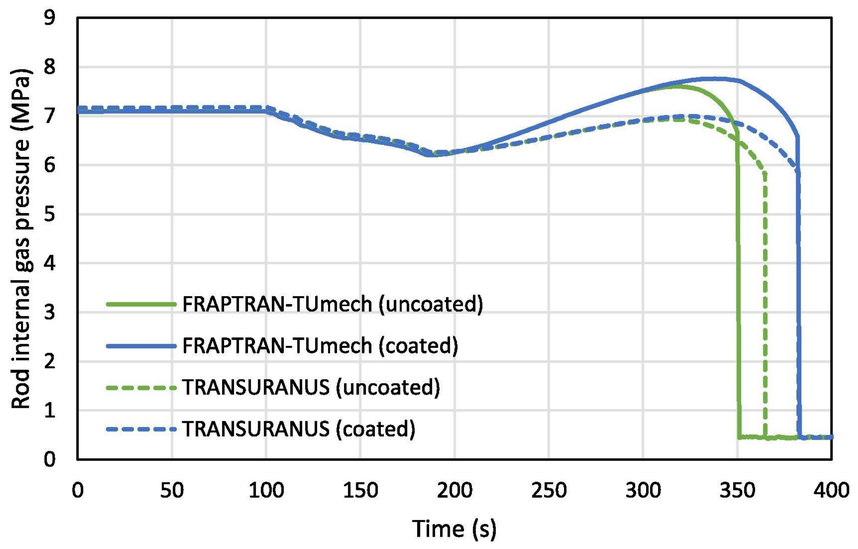

Figure 3. Predicted rod inner pressure evolution for Cr-coated and uncoated cladding under IFA-650.10 test conditions.

Models and correlations for Cr-coated Zircaloy were also implemented into TRANSURANUS. The extended code was used to simulate two LOCA tests: QUENCH-L1 (out-of-pile test on fresh Zircaloy) and IFA-650.10 (in-pile test on high-burnup Zircaloy-UO_2), enabling a comparative performance analysis between coated and uncoated cladding.

3. Advanced calibration methodology

A calibration methodology developed within the APIS project has been tested to calibrate the fission gas release model in TRANSURANUS using commercial data from Westinghouse. The results confirm the methodology is suitable for calibrating fuel performance codes intended for industrial applications.

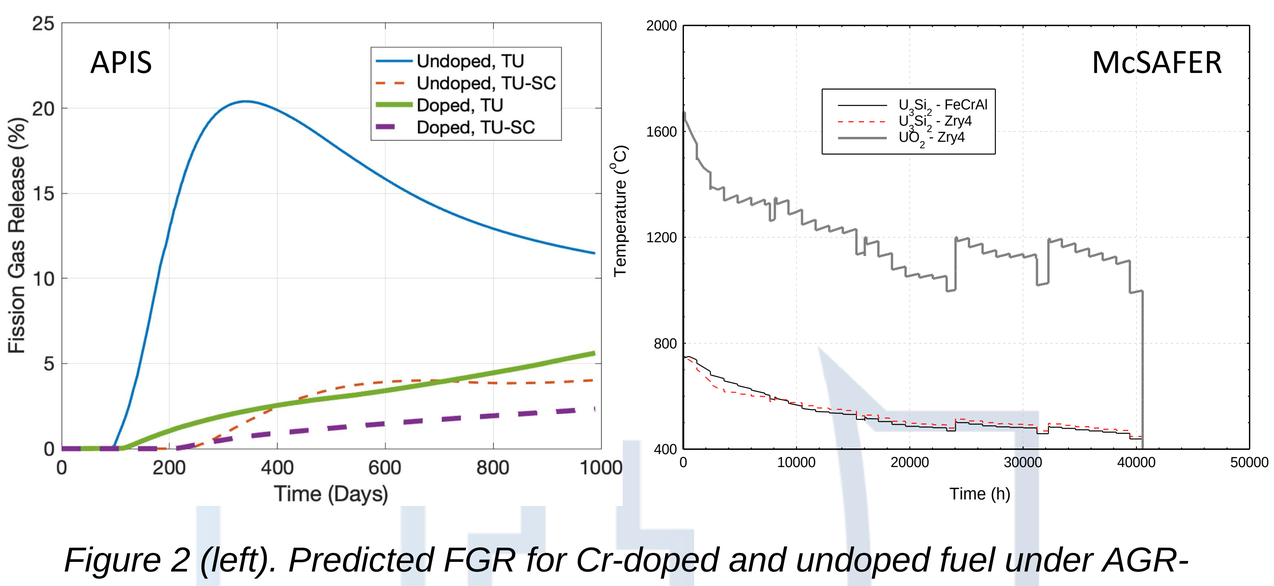

Figure 2 (left). Predicted FGR for Cr-doped and undoped fuel under AGR-like FHR normal operating conditions. Figure 2 (right). Predicted fuel centreline temperature evolution for UO_2-Zry4 and U_3Si_2-FeCrAl under a simplified irradiation history (FUMEX-II).

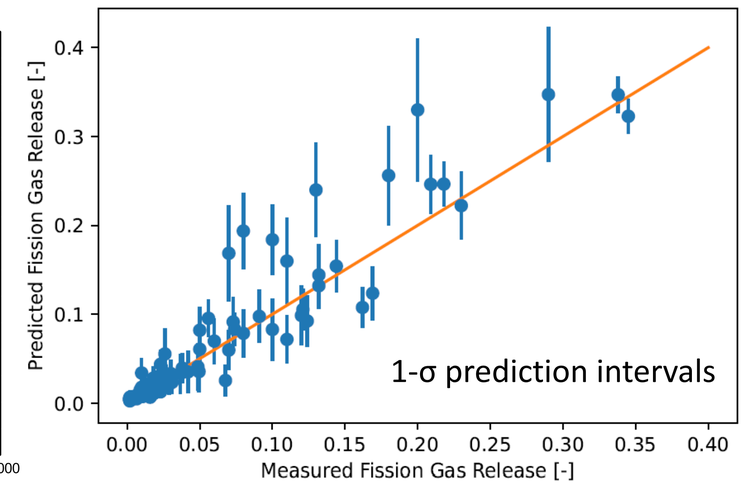

Figure 4. Best-estimate predictions plotted against fission gas release measurements.

Acknowledgments

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