Validation of ALEPH2 burn-up code using benchmarks from SFCOMPO

Linde Pollet

Master of Nuclear Engineering Technology

Introduction

Spent Nuclear Fuel (SNF), irradiated nuclear fuel, is highly radioactive and dangerous when not handled correctly. A correct characterization of SNF, in terms of nuclide composition, gives the possibility to accurately quantify integral responses such as decay heat, neutron and gamma emission and criticality for its safe handling, transport, and storage. So-called depletion codes are used to predict these nuclide compositions. ALEPH2 is a Monte-Carlo depletion code developed by SCK CEN since 2004. In the past, ALEPH2 has been validated with a limited number of light water reactor (LWR) cases. As a part of its maintenance and verification process a continuous work of validation against experimental measurements is needed.

Method

In this Master's thesis, a validation exercise was performed by simulating several LWR SNF benchmark cases using the experimental assay data available in SFCOMPO, a database developed and maintained by the OECD/NEA. Experimentally measured nuclide compositions were compared against ALEPH2 calculations. Initially, a simple model was developed for each case, which, after analysis, was refined. Two of the four cases are discussed. For every case, the position in the assembly and the power to the sample is given.

Gösgen-1 GU3 sample

The sample was irradiated in two different assemblies, the position of the sample was changed while the reshuffling (Figure 1). The power history is given in Figure 2 and the boron concentration in the fuel assembly in Figure 3.

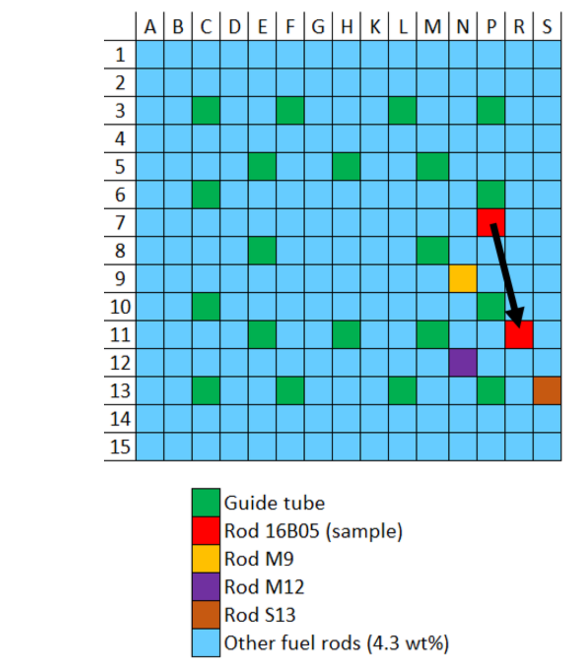

Figure 1: Overview of rod replacement in Gösgen-1 GU3 from assembly 1601 to 1701 before cycle 18

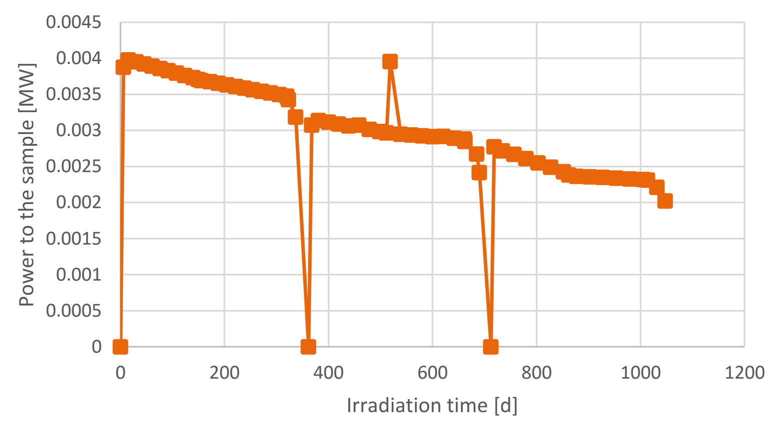

Figure 2: Power history of GU3 sample

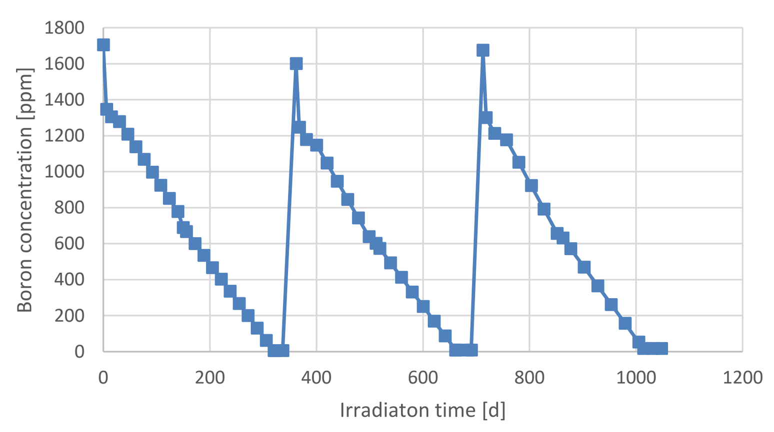

Figure 3: Boron concentration in the fuel assembly

Beznau-1 BM5 sample

The sample was irradiated in an assembly for which incomplete information about material composition were given. Therefore several assumptions had to be made (Figure 4). The power history is given in Figure 5 and the boron concentration in Figure 6.

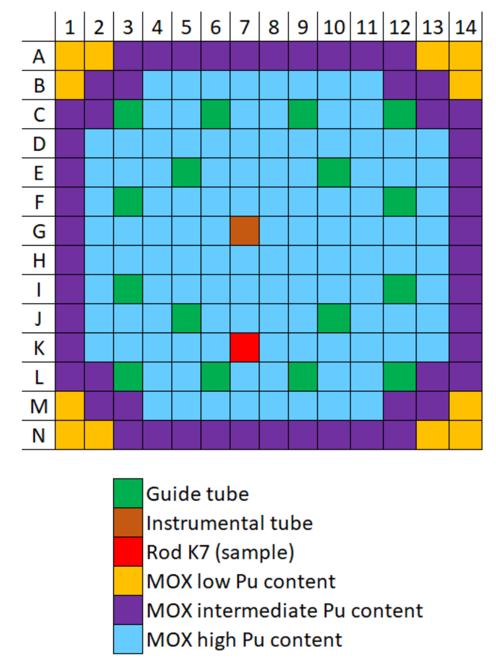

Figure 4: Assembly overview with sample BM5 in rod K7

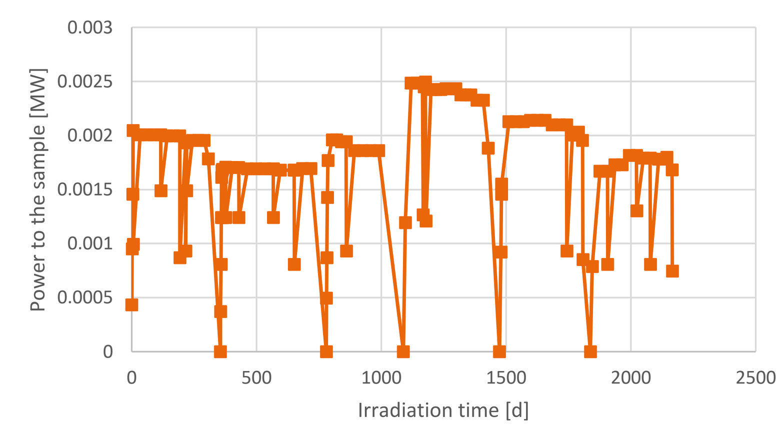

Figure 5: Power history of BM5 sample

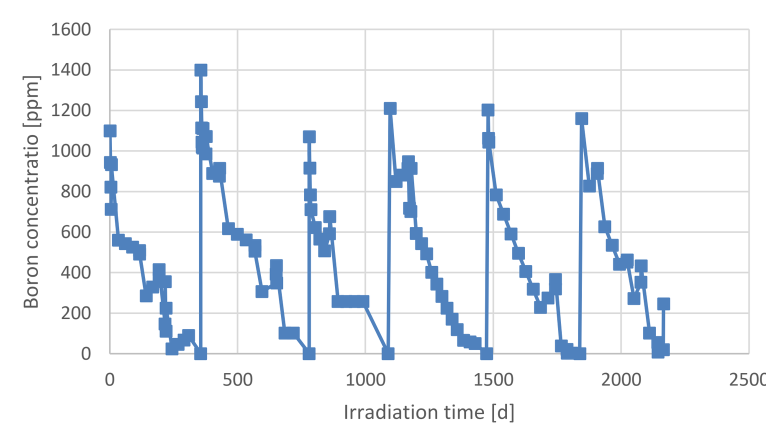

Figure 6: Boron concentration in the fuel assembly

Results

The results are presented in the form of C/E-1 per case, to represent the deviation of the results from simulation against the experimental ones. For both models, experimental results were available both at analysis date (AD) and at the day of discharge (End of Life, EOL). These results are obtained by using the ENDF/B-VII.1 nuclear data library. For each of the cases, a first simulation was run with the given irradiation history and then, another one normalized to the experimental ^{148}Nd concentration, an isotope commonly used as burn-up tracer.

Gösgen-1 GU3 sample

Figure 7 shows the C/E-1 for the fission products, both for the simple model and for the refined case. The sample burn-up provided through the ALEPH2 simulation is 50.7 GWd/tHMi. The simple model already provided good agreement with the experimental results. Results after refining are similar to the results of the simple model.

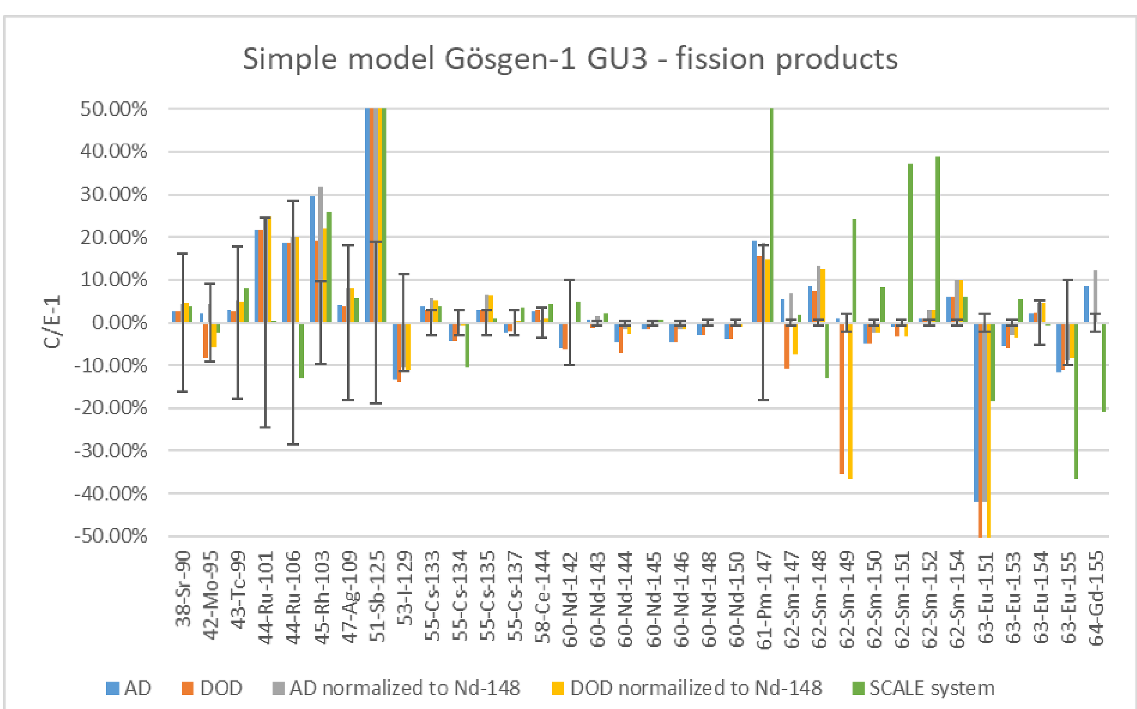

Figure 7: C/E-1 results optimized model Gösgen-1 GU3 – fission products

Beznau-1 BM5 sample

Figure 8 shows the C/E-1 for the actinides, for the two different decay periods of the rest of the fuel assembly before the irradiation. The sample burn-up provided through the ALEPH2 simulation is 60.35 GWd/tHMi. Considering the initial uncertainties and large modeling assumptions made for this case, the nuclide composition of the sample is well predicted.

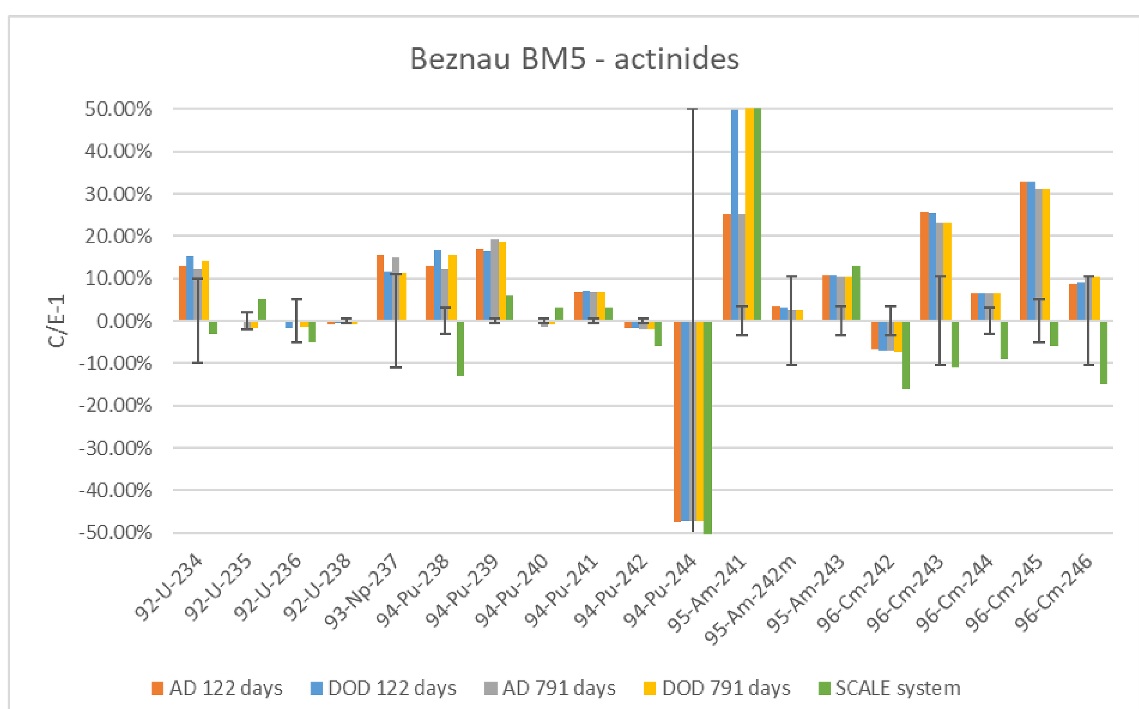

Figure 8: C/E-1 results Benzau-1 BM5 - actinides

Conclusion

Good agreement was found between the calculated and measured nuclide compositions for the four LWR SNF cases. Deviations from experimental data satisfy the current requirements. Therefore, new implementations in ALEPH2 have been successfully validated.

Supervisors / Co-supervisors / Advisors

Gert Van den Eynde
Pablo Romojaro, Luca Fiorito