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A New Cross Sections Database for the Simulation of MSRs within the NMB Code

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The Nuclear Material Balance [1] (NMB) code is a nuclear fuel cycle simulator developed by the former Tokyo Institute of Technology (present Institute of Science Tokyo) and the Japanese Atomic Energy Agency. The code allows the simulation of the full nuclear fuel cycle, including front-end, reactor and back-end operations for an extended number of reactor designs, fuels, reprocessing and disposal strategies. Presently, the burn-up matrix used in the NMB depletion calculations, is constructed through microscopic cross sections catalogues analogue to the ORLIBJ40 [2] database, where the data is tabulated for various isotopes, nuclear reactions, types of nuclear reactors and fuel burn-up, nor requiring therefore to perform neutron transport calculations. While this approach is perfectly suitable for the simulation of solid fuel reactors, it is limited for the simulation of Molten Salt Reactors (MSRs), where online fuel treatment is typically a requirement, and should be tracked during burn-up. A few examples of material flows include the removal of volatile fission products from the fuel, the removal of insoluble fission products through fuel treatment, and the refueling. Different codes were developed for the investigation of MSR fuel cycles, as EQL0D [3], a MATLAB-based wrapper for Serpent2 developed at the Paul Scherrer Institute with the scope of studying MSRs fuel cycles. While front and back-end are not simulated, such codes provide high detail reactor calculations and databases, such as burn-up dependent depletion matrices including modifications for online reprocessing streams.
A valid option for MSRs depletion calculations in the NMB routine, is to construct the burn-up and material-flows dependent burn-up matrices with the support of codes specialized in MSR fuel cycle calculations, and include them directly in NMB. To do so, EQL0D was used to simulate the fuel cycle of several MSR types until equilibrium, for several burn-up steps and several material exchange rates for gaseous FP removal, soluble FP removal, and refueling patterns. For each of these calculations, the EQL0D burn-up matrices were extracted, and analyzed, and formatted for NMB compatibility. On top of having a new cross section catalogue for the deployment of MSRs in NMB, the production of the present database allowed to study the influence of refueling patterns and burn-up for specific isotopes and reactions.

References

[1] Okamura,T. et. al. (2021) EPJ Nuclear Sciences & Technologies. 7. 10.1051/epjn/2021019.
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[3] Hombourger, B. et al. (2020). Annals of Nuclear Energy, 144, 107504.

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