Master's Thesis Engineering Technology

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Cycle study of BEAVRS benchmark using different energy deposition models with the OpenMC code

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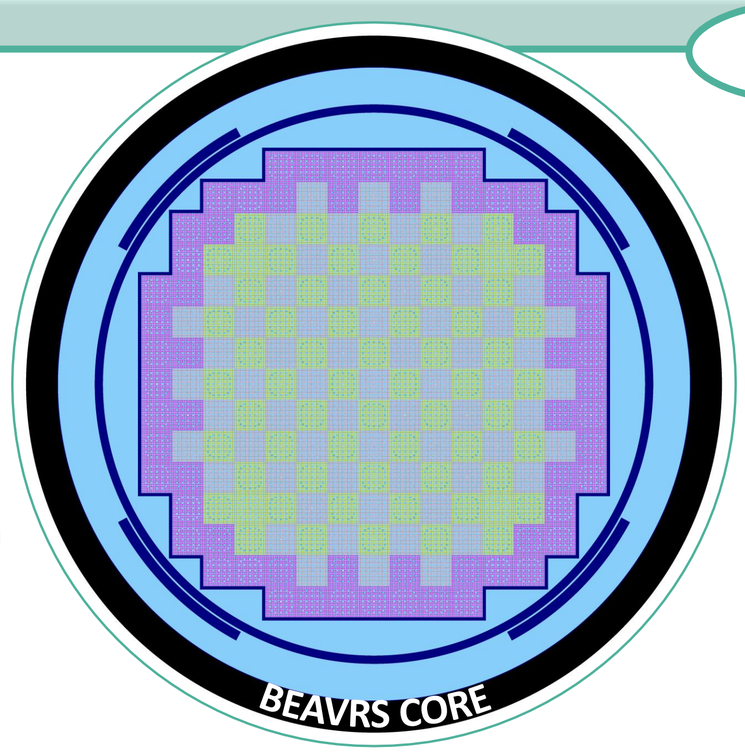
INTRODUCTION

Depletion simulations of nuclear systems in Monte Carlo codes use energy deposition models. The energy deposited in the fuel is inevitably linked to the power in the material and therefore the level of burn-up of the fuel. The chosen Monte Carlo code is OpenMC, a relatively new, open-source, community-developed code.

The aim of this master's thesis is to investigate the influence of two energy deposition models on three observables of interest in a reactor core:

1. **Criticality**
2. **Isotopic Inventory**
3. **Fission parameters (flux, fission rate, heating)**



EDEP mode 0 assumes that all energy is deposited locally in the fuel.

MATERIAL&METHOD

MATERIAL

- OpenMC code
- HPC-infrastructure of the VSC (Flemish Supercomputer Center)

METHOD

1. Build full 3D model of BEAVRS benchmark
2. Deplete for one time-step at the time
3. Determine critical boron concentration
4. Construct boron letdown curve
5. Inspect isotopic inventory
6. Inspect fission parameters in two assemblies

→ Repeat process for two energy deposition models

EDEP mode 3 assumes that photons deposit their energy at the end of their track and that neutrons undergo reactions along their track.

RESULTS

ISOTOPIC INVENTORY

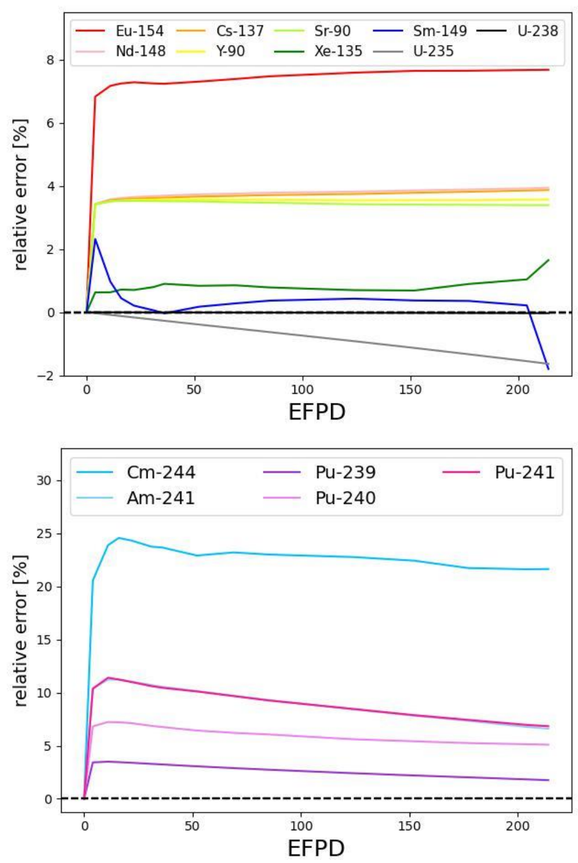


Figure 1: Isotopic inventory – relative error fission products and uranium (top) relative error actinides (bottom)

CRITICALITY

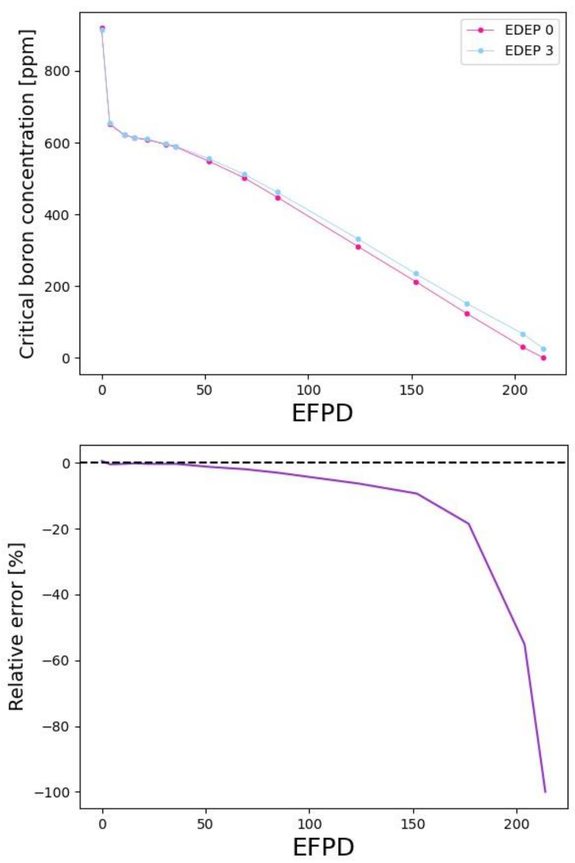


Figure 2: Boron letdown curve for both modes (top) relative error (bottom)

FISSION PARAMETERS

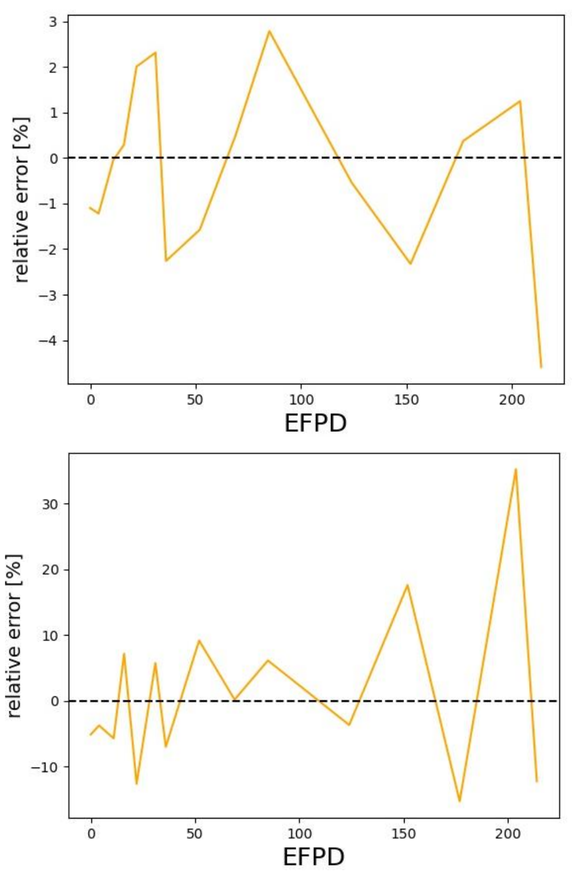


Figure 3: Fission parameters - relative error for central assembly (top) relative error for top right assembly (bottom)

CONCLUSION

It can be concluded that the different energy deposition models do have a **significant effect** on the observables. If one assumes that the energy is solely deposited locally, the power in the fuel is overestimated. This leads to an overestimation of the reaction rate and therefore an **overestimation of the burn-up**. This results in an underestimation of U-235, U-238 and Sm-149 and an overestimation of the other researched nuclides.

Because of the underestimation of U-235 and overestimation of Xe-135, the criticality of the core is underestimated. This results in a **lower critical boron concentration**. The isotopic inventory is important for transport, storage, disposal and reloading. An inaccurate isotopic inventory can cause severe safety problems.

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