Neutronics analysis of demonstration and experimental fast reactors with transport methods

Summary

Zoltán István Böröczki
Supervisor: Dr. Máté Szieberth

Lower-order approximations of the angular-dependent flux, such as diffusion theory, are often applied for perturbation theory calculations or transient simulations. However, in a wide range of problems, the diffusion theory does not provide adequate results, and the application of higher-order transport approximation is recommended. I have developed the SEnTRi code coupled with the PARTISN discrete ordinate deterministic neutron transport solver to perform the above-mentioned calculations for fast-spectrum reactors. The dissertation presents the applicability of the SEnTRi code in various areas of the safety analysis of fast reactor concepts. The effect of the angular and spatial discretisation of the angular-dependent flux on the results of perturbation theory calculations in sensitivity and uncertainty analysis is also investigated. Furthermore, the extension of the SEnTRi code has begun to perform coupled thermal-hydraulic calculations on fast reactors.

In order to perform a deterministic calculation, group constants must be prepared previously. The assumptions and the modelling during the homogenisations and the energy group condensation will highly affect the final group constants and, therefore, the accuracy of the deterministic calculations. The majority of the codes available for homogenised group constant generation for deterministic transport calculations apply the approximation of scalar flux weighting during energy group condensation of higher-order anisotropic scattering matrices. This condensation significantly affects the final results of the higher ordered transport calculations and is investigated in the dissertation.

The effect of the angular and spatial discretisation on the results of perturbation theory calculations is also studied with the help of the SEnTRi code. The accuracy of the calculations with the different angular flux discretisation options, namely discrete ordinates representation and spherical harmonics, are crucial from the viewpoint of perturbation theory and transient simulations.

Sensitivity and uncertainty calculations were performed for the Comet Critical Assembly and the ALFRED reactor core. Reactivity coefficients and their uncertainties originating from the nuclear data were determined using several codes and methods, and the properties of these fundamentally different calculations are presented.

Reactor kinetic codes are crucial in safety assessment. Validation calculations of the SEnTRi for a low power transient measured at the BME Training Reactor were performed, and the extension of the code began to perform coupled thermal hydraulic calculations on fast reactors. To test the newly developed features of the code, the simulation of an asymmetrical control assembly withdrawal transient of the ALLEGRO reactor was chosen, and the effect of applying diffusion or higher-order transport approximation was also investigated.