Implementation of SP_3 method calculation capability to FRBurner module of CBZ code system: (2) Component-wise sodium void reactivity results investigation and comparison

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We find the SP_3-Perturbation method could give well-agreed results on sodium void reactivity calculation comparing to the results given by the transport theory solver. The key point is how to categorize two types of scattering-component reactivity. This discovery is studied with four fast reactor cores provided by one OECD/NEA benchmark under various methodologies.

Keywords: SP_3, perturbation theory, void reactivity, component-wise

1. Introduction

The Simplified-P_N (SP_N) theory was proposed initially through replacing the 1D differentiation operator in P_N equations with 3D gradient operator without adequate mathematical derivation, but theoretical basis has been built recent years[1]. The SP_N method processes diffusion theory-type equations but could consider angular neutron flux to a certain extent. In our previous study, we chose SP_3 and developed a SP_3-Perturbation method in the CBZ code system for void reactivity calculation based on the SP_3 and perturbation theories. In the SP_3 theory, there are two types of neutron fluxes, they are called as ϕ^0 and ϕ^2, respectively. The scattering component of void reactivity, accordingly, can be divided in two parts: ϕ^0-scattering and ϕ^2-scattering. The reliability of the SP_3-Perturbation method has been confirmed already[2]. We find the SP_3-Perturbation method gives better-matched results on scattering component void reactivity than the diffusion theory does in recent works.

2. Numerical experiment

We made investigations about the component-wise void reactivity and found that the SP_3-Perturbation method result matches the transport method result well if categorizing the ϕ^2-scattering as non-leakage component. We create a series of ring-like problems based on two fast reactors, MET-1000 and MOX-1000, described in one OECD/NEA benchmark. In these calculations, cores are modeled as two-dimensional cylindrical model. We study the characteristic of the SP_3-Perturbation method through setting the voided region as a ring-layer at various locations inside the cylindrical core, which means the dominant components of void reactivity are different from each region. We want to find out the advantage of SP_3-Perturbation method on void reactivity analysis through these ring-like problems.

3. Result

Figure 1 shows that on the sodium void reactivity calculation the SP_3-Perturbation method gives closer result to the transport theory method result than the diffusion theory method in most void cases, especially in the outer core regions (from region 25 to 44). At present, we think the evidence of clear advantage of the SP_3-Perturbation method is not adequate. For instance, the region 30-34 in the MOX-1000 calculation, the SP_3-Perturbation method gives worse result than the diffusion theory does, which may suggests that the SP_3-Perturbation method can be affected by core configuration. Thus, we are going to further investigate this discovery through a true 1-dimensional model problem with more fast reactors soon to show the generality.

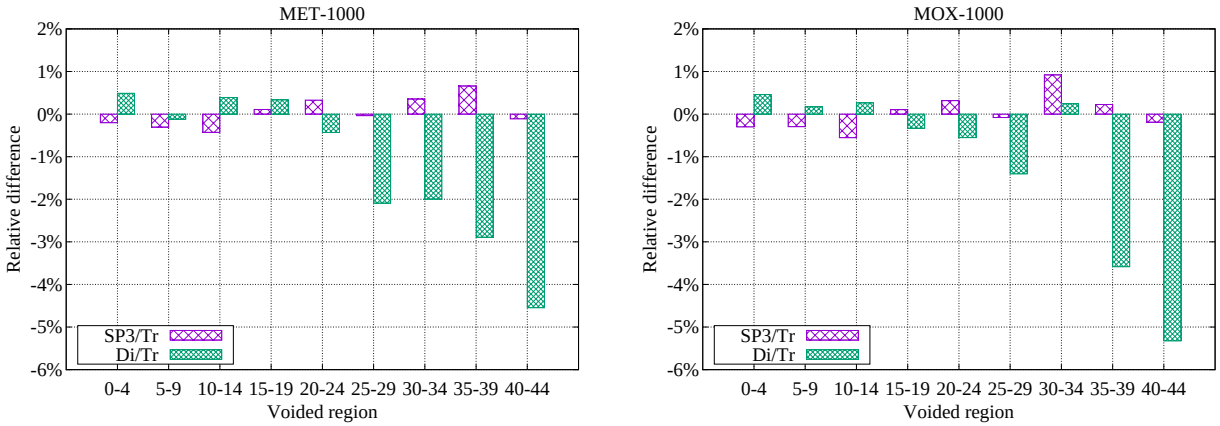

Figure 1: Relative difference on scattering component void reactivity of the SP_3 and diffusion theories result to the transport theory result in ring-like model.

Reference

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