Verification of FRBurner module of CBZ code system: MET-1000 core calculation based on OECD/NEA benchmark report

*Junshuang FAN[1], Chiba Go[1]
[1]Hokkaido Univ.

New module of reactor code system CBZ for fast reactor burn-up calculation is designed recently. It is designed for our future work about new fast reactor core design. We verified accuracy of this new module and show some results.

Keywords: burn-up calculation, verification, k_{eff}, reactivity.

1. Introduction

CBZ is a general-purpose reactor physics code system and FRBurner module is designed for fast reactor burn-up calculation recently. And we need to verify this new module for accuracy. We choose OECD/NEA benchmark work[1] and evaluation work[2] of this benchmark from JAEA as our verification calculation reference. Important reactor physics parameters and heavy metal inventories at EOC are compared to JAEA's evaluation work. MET-1000 is one middle size benchmark fast reactor core design with metallic fuel which was developed from the reference Advanced Burner Reactor(ABR) concept. Core layout of MET-1000 is shown in Fig 1.

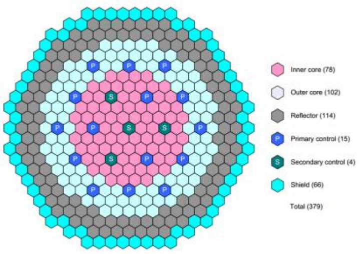

Fig 1. Core layout of MET-1000

Table 1. Comparison between FRBurner result and evaluation work

Parameters	Reference (Most detailed)		FRBurner			
	BOC	EOC	BOC	Error	EOC	Error
k_{eff}	1.0301	1.0092	1.0221	-0.78%	1.0033	-0.58%
$\beta_{effective}$	339	338	332	-2.1%	331	-2.1%
$\Delta\rho_{Na}$(pcm)	2153	2243	2090	-2.9%	2170	-3.3%
$\Delta\rho_{doppler}$(pcm)	-360	-374	-348	-3.3%	-354	-5.3%

Calculation with FRBurner was conducted by approximate 2D cylinder core model. In evaluation work, base calculation is defined as homogeneous lattice model ,3D core calculation, diffusion solver with 70 energy groups. Heterogeneous lattice model, transport correction with ultra-fine group correction is the most detailed calculation.

Table 1 shows results of FRBurner compared to most detailed calculation in evaluation work. Notice that FRBurner calculation result is much closer to base calculation condition due to the calculation condition are similar with each other. Heavy metal inventory also shows high level agreement. Comparison with base calculation and HM inventory are not listed here due to space limitations but all relative differences are less than 1%.

2. Conclusion

FRBurner calculation result shows less than 1% and 3% errors on k_{eff} and β_{eff} respectively. Sodium void worth reactivity and doppler reactivity calculation of FRBurner shows less than 10% errors. Heavy metal inventory result is highly consistent with evaluation work(less than 0.4%). We believe that FRBurner module could get acceptable result on fast reactor burn-up calculation under 2D cylinder homogeneous model with diffusion method calculation condition.

Reference

[1] Bernnat, Wolfgang, et al.(2016). Benchmark for Neutronic Analysis of Sodium cooled Fast Reactor Cores with Various Fuel Types and Core Sizes(Report Number: NEA/NSC/R(2015)9).

[2] Uematsu, et al.(2015). Evaluation of OECD/NEA/WPRS benchmark on medium size metallic core SFR by deterministic code system Marble and Monte Carlo code: MVP. Tada Kenichi, Chiba Go & Yamamoto, Akio (Eds.). Japan