Verification and sensitivity investigation of FRENDY-V2/GENESIS for sodium-cooled fast reactor fuel assembly

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The applicability of FRENDY-V2/GENESIS for sodium-cooled fast reactor fuel assemblies was verified. Results showed good agreement with MVP3 for the infinite multiplication factor and the pin-wise fission reaction rates. Sensitivity analyses among various calculation conditions were performed, and it was found that the selection of energy group structure had the greatest impact.

Keywords: FRENDY Version 2, GENESIS, sodium-cooled fast reactor, neutron current method, JENDL-5.

1. Introduction A previous study confirmed the applicability of FRENDY-V2/GENESIS for LWR fuel assemblies [1]. FRENDY-V2/GENESIS is the direct coupling code system of nuclear data processing code FRENDY Version 2 and the three-dimensional MOC-based transport calculation code GENESIS. This study confirmed the applicability of the same calculation procedure to sodium-cooled fast reactor fuel assemblies. The infinite multiplication factor (k_{inf}) and pin-wise fission reaction rate (R_f) were compared with the reference results and the impact due to various calculation conditions on them were also quantified.

Table 1. Difference of k_{inf} between various energy group structures. (Statistical error (MVP3): ±0.0011%)

# of energy group	difference (%)
302	-0.036
175	-0.096
70	0.261

2. Calculation method and result The macroscopic cross sections for each medium were generated using FRENDY-V2 with SCALE 302 group, VITAMIN-J 175 group, and JFS 70 group structures. The resonance interference effect between multiple nuclides was considered in FRENDY-V2 calculations. The fuel pellet media were treated as different resonance media. The neutron current method [2] was applied to calculate the Dancoff factors by GENESIS. The background cross-sections used in FRENDY-V2 were calculated based on the approximation formula to Carlvik's rational two-terms approximation. The MOC calculations were performed by GENESIS. The reference results of k_{inf} and R_f were given by MVP3. Sensitivity analyses indicated that the selection of energy group structure had the largest impact on calculation results. For each energy group structure, differences of k_{inf} indicated the current analysis procedure simulates accurately (Table 1). Less than 50 pcm difference result can be obtained with 302 group calculation. As for pin-wise R_f spatial distribution, although 0.16% level tilt was observed (Fig. 1). It was also reveals that R_f on the center region was underestimated, and that on the peripheral regions was overestimated in 70 group calculation. However, it was insignificant for the practical use.

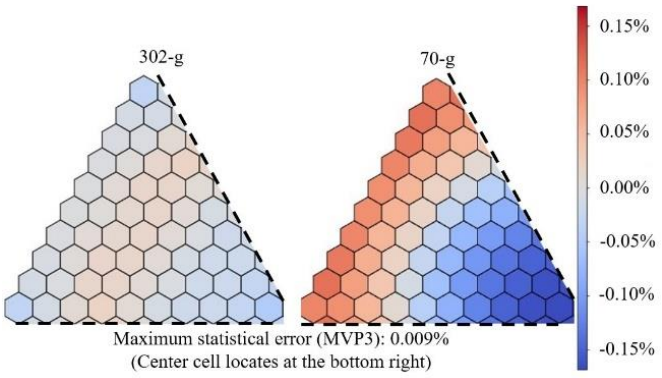

Figure 1. Pin-wise R_f differences of 302 group (left) and 70 group calculations (right).

3. Conclusion The applicability of FRENDY-V2/GENESIS for sodium-cooled fast reactor fuel assemblies was verified as an extension work. Enough accurate results were obtained in comparison with MVP3. Sensitivity analyses of various calculation conditions were investigated, and it was confirmed the group structure had largest impact on k_{inf} and R_f. Although the spatial tilt of pin-wise R_f differences was observed in 70 group calculation, it is considered insignificant for the practical use.

References [1] Fujita, T., et al, (2024). [published online] JNST. [2] Sugimura, N. et al, (2006). JNST, 43(10), 1182–1187.