Verification of RAST-K hexagonal transient solver with OCED/NEA benchmark problem of KALININ-3 NPP

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ABSTRACT

This poster presents the verification results of our in-house code RAST-K for Kalinin-3 NPP Benchmark compared to ATHLET/KIKO3D and PARCS nodal codes. Kalinin-3 NPP is one of OECD/NEA benchmark problems and has a hexagonal FA geometry. The purpose of this poster is to assess the performance of a newly developed RAST-K transient module compared with other developed code systems. PARCS code is used for code-to-code comparison. This poster contains the calculation results at hot zero power (HZP) condition. The transient calculation scenario in this study is based on ejection of the control rod bank with the largest rod worth.

Code system

- RAST-K v2.0 is our in-house nodal code that has been validated and verified using nuclear design reports and other available code systems.
- Hexagonal geometry analysis solver in RAST-K has been developed based on TPEN method.
- The solver has already been verified for MOX-3600, CAR-3600, MET-1000, and MOX-1000 at steady state condition.
- Transient calculation module of RAST-K is developed based on transient fixed source problem

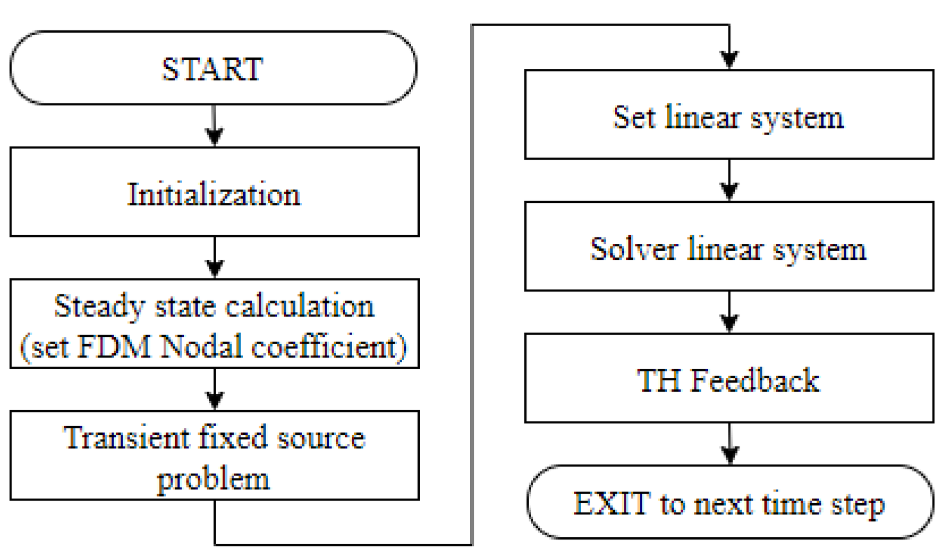

Fig. Flow chart

Specification of benchmark model

● Core specification

- Six different types of fuel assemblies are used for Kalinin-3 NPP
- Notation of X is the control rod bank 10.
- The calculation is performed with 82.95% inserted control rod bank 10 from bottom of active height.

● Fuel assembly (FA) specification

- One fuel assembly contains 312 fuel pins, one central instrumentation tube and 18 guide tubes. FA03, FA04 and FA05 are loaded with 5 wt.% gadolinia fuel.
- FA03 and FA04 contain nine gadolinia rods, FA05 contains six gadolinia rods.

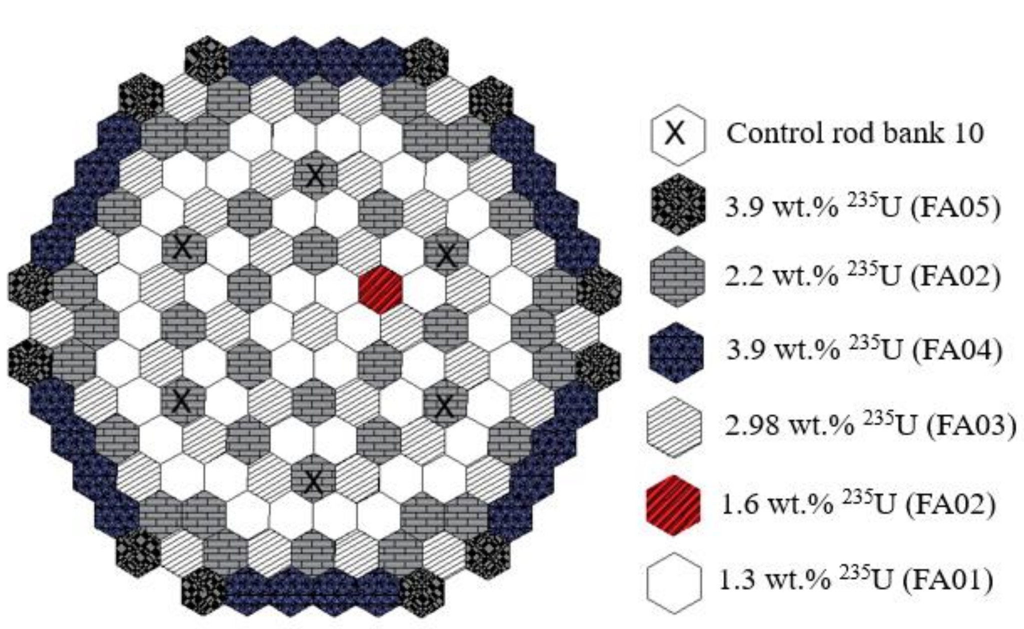

Fig. Radial layout of Kalinin-3 NPP

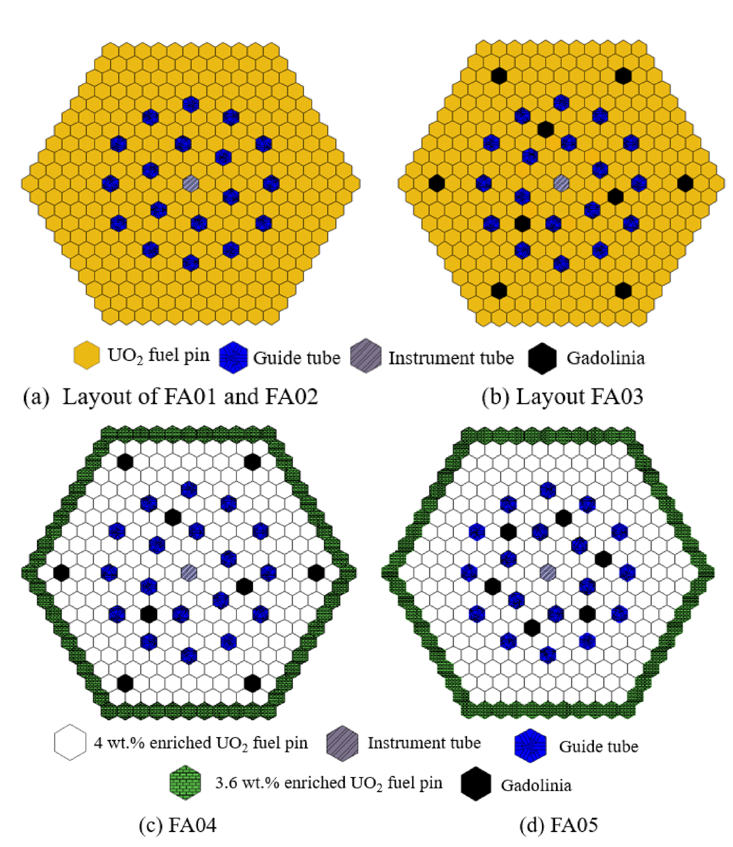

Fig. Radial layout of Kalinin-3 FAs

● Cross section data file with control rod

- OECD/NEA provides the cross-section data file for 96 EFPDs.
- Assembly discontinuity factor (ADF) and corner discontinuity factor (CDF) are fixed as one in this calculation.
- Benchmark problem provides the cross-section (XS) library in NEMTAB format and contains 64 XS sets

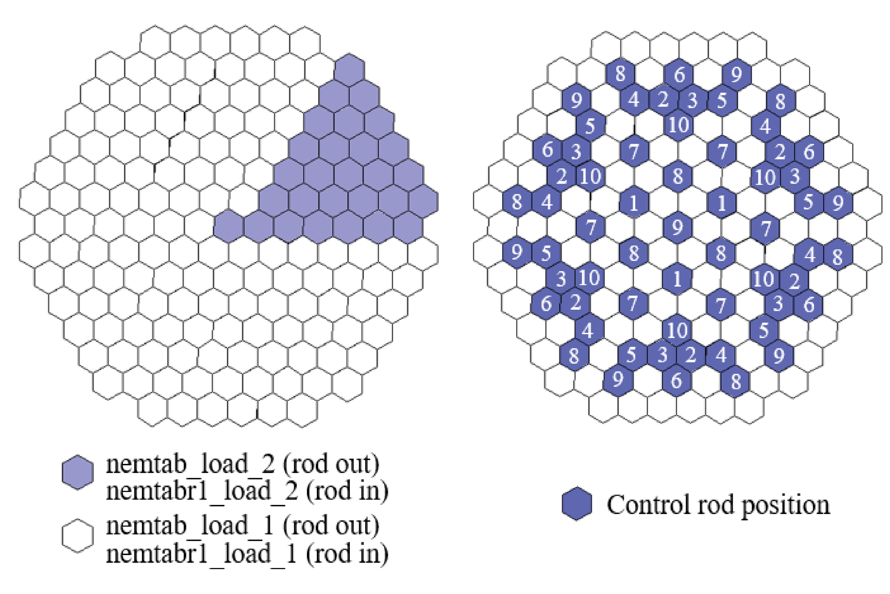

Fig. Cross-section data position with control rod bank

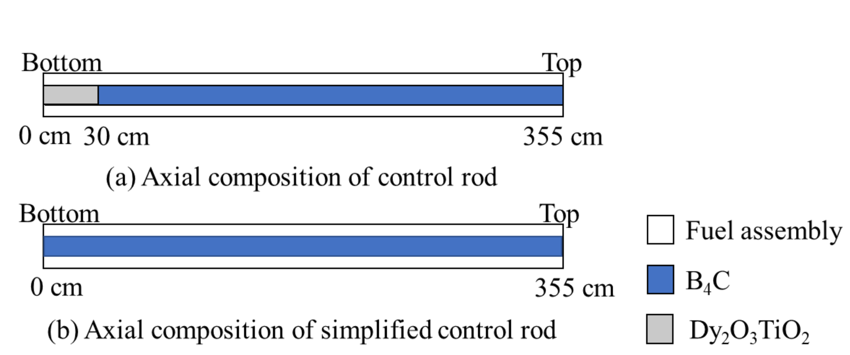

Fig. Axial composition of control rod

Calculation results

■ Multiplication factor

Table. Multiplication factor with inserted control rod bank 10

Code system	keff	Difference [pcm]
ATHLET/KIKO3D	1.00770	
RAST-K	1.00841	71
PARCS	1.00865	95

■ Transient calculation with CR bank #8

- As shown in the table, the control rod bank #8 has the largest rod worth. Therefore, control rod bank #8 is used for rod ejection calculation. The keff of all rod out condition is 1.00965.

Rod bank	Rod worth [pcm]	Rod bank	Rod worth [pcm]
1	571	6	1148
2	226	7	1120
3	1151	8	1609
4	1084	9	1171
5	1085	10	1174

- Control rod bank #8 is being ejected from 0 cm of active height to 355 cm during 0.1 second. The time step of 0.025 second is used for calculation and power condition is presented in Figure 8.
- Compared to the results calculated using PARCS code, the relative difference of power is within ±0.2%.
- Right-side y value contains the reactor power divided by nominal power
- Maximum power level reached 7000% of nominal power condition.

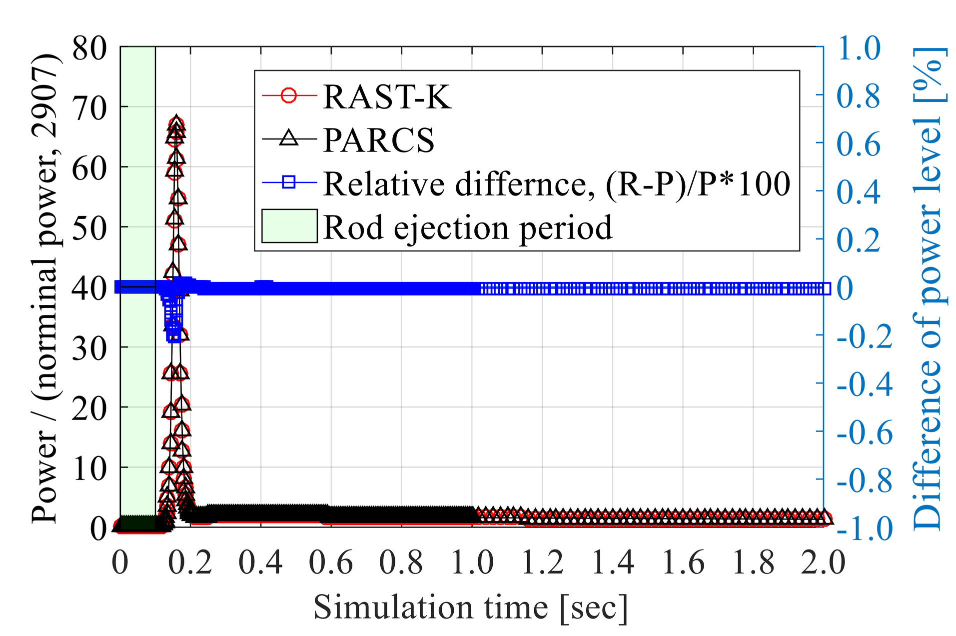

Fig. Core power of during rod bank ejection

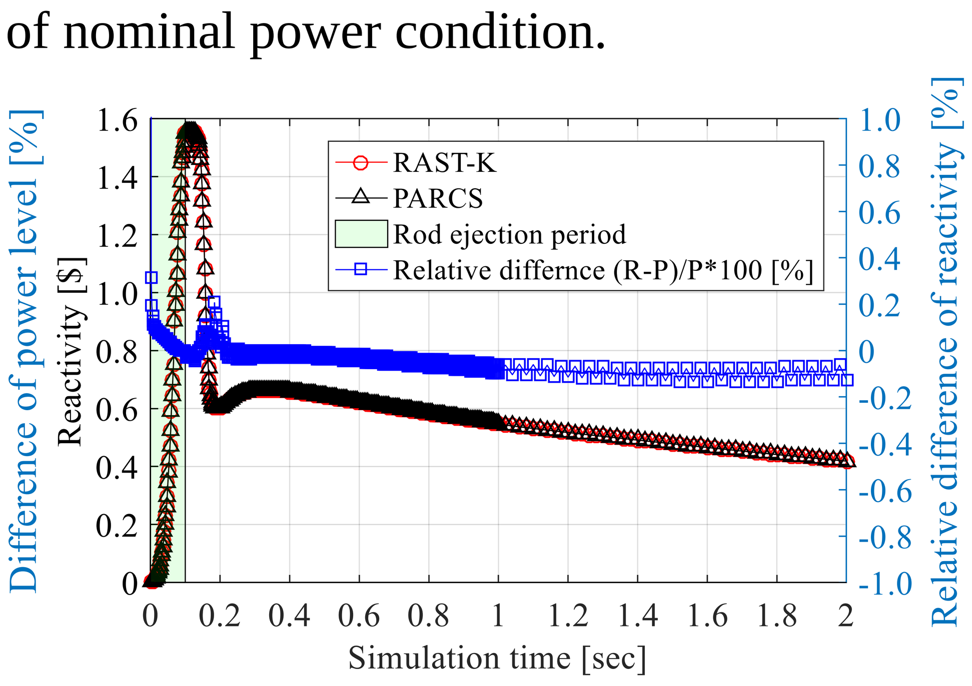

Fig. Total reactivity difference during rod bank ejection

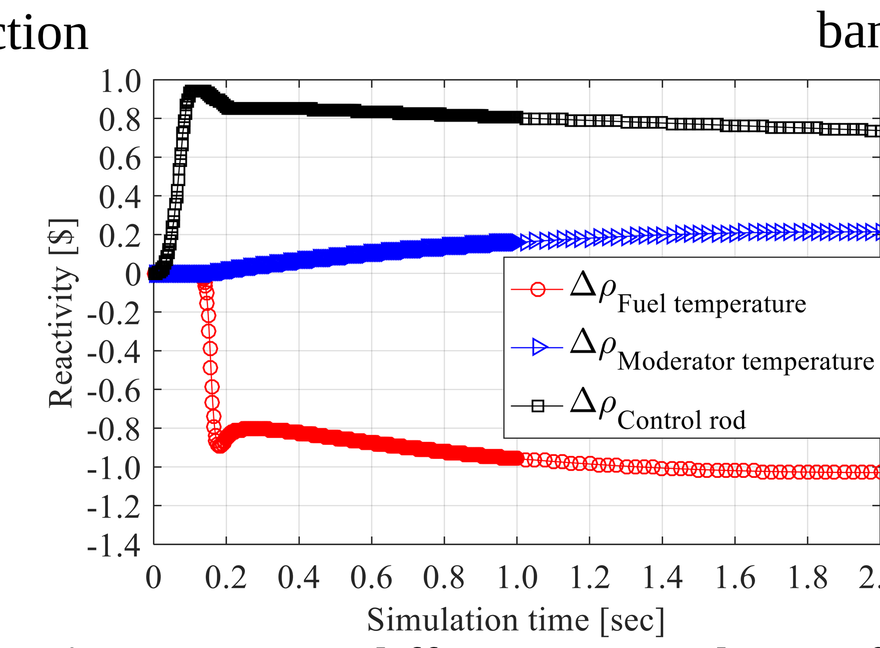

Fig. Reactivity difference according to fuel

DISCUSSION AND SUMMARY

■ Three major analyses are performed in this poster: (1) a comparison of multiplication factor with ATHLET/KIKO3D and PARCS at HZP condition, (2) a comparison of radial power distribution with a nodal code PARCS, and (3) sample rod ejection calculation using the highest rod worth control rod bank. In HZP condition, the multiplication difference of RAST-K is 71 pcm compared to ATHLET/KIKO3D and 24 pcm compared to PARCS. In addition, the maximum observed radial power difference between PARCS and RAST-K is 0.5%. Finally, the maximum difference of reactivity in sample rod ejection scenario was found at ±0.2%.

■ This study demonstrates a successful verification of the transient calculation module implemented in RAST-K for hexagonal geometry as compared with PARCS and ATHLET/KIKO3D.