Data and Method of MVP-BURN Calculations for Pin Cell Benchmark Problems

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1. Code descriptions

MVP-BURN [1,2] is a coupling code of a continuous-energy Monte Carlo code MVP [3,4] and a burn-up calculation module BURN [2] which solves a depletion equation analytically based on the modified Bateman's method with microscopic capture, fission and (n,2n) reaction rates obtained with MVP. The MVP-BURN is well validated by several burn-up benchmark calculations and analyses of post irradiation experiments [1]. Features of this code are as follows:

- Very fast computation is realized on vector and / or paralleled computers. [5]
- MVP library for arbitrary temperatures can be internally generated. [5]
- Burn-up calculation can be applied to the system including a great many coated fuel particles (ex. HTTR: high-temperature engineering test reactor in JAERI) with the statistical geometry model [6].
- Geometry and material composition can be changed during burn-up (ex. motion of control rod, boron concentration, void fraction, fuel temperature distribution, etc.).
- Branch-off calculation is supported to estimate instantaneous reactivity changes at any burn-up time-step point.
- Predictor-Corrector method can be applied to any burn-up duration for accurate and efficient calculation for the system including burnable poison.
- Burn-up chain model can be easily changed according to reactor types and computer resources.

2. Calculation conditions for the pin cell benchmark problems

1) Basic data library version;

JENDL-3.2 for all nuclides (energy range from 1.0E-5eV to 20MeV)

2) Data processing code

LICEM ; Neutron Cross Section Library Production Code System[7] for Continuous Energy Monte Carlo Code MVP. The LICEM system includes the following sub-codes; LINEAR, RECENT, SIGMA1, ACER-J, U3R-J, THERM-J, etc.

3) Depletion calculation

- number of depletion zone; 1 (fuel)
- number of depletion nuclides (chain model);

20 heavy nuclides from U-234 to Cm-245 and 35 fission products including 4 pseudo FPs. Five nuclides (U-234, Cd-113, Pr-143, Nd-143, Nd-145) are added in the chain model appeared in Ref.[1]

Point-wise cross sections are used for all nuclides, however, cross sections of the pseudo fission products are generated from 107-group constants (JENDL-3.2) of the SRAC code. (see Ref.[1]).

- time step width for MVP-BURN calculation

0.1, 0.5, 1.0, 5.0, 10.0, 15.0, 20.0, 25.0, 30.0, 35.0, 40.0, 50.0, 60.0, 70.0 GWd/t

The Predictor-Corrector (PC) method was applied for all time steps.

In the PC-method, MVP calculations are done twice in each time step (beginning of step and end of step) to get averaged microscopic reaction rates during a burn-up time step interval. Each time step is furthermore divided into several sub-steps for solution of depletion equation.

4) Neutron histories in each MVP calculation

5,000,000 = 500 batches * 10,000 particles/batch

(including initially skipped 5 batches)

References;

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