Fuel Performance Analysis of BEAVRS Benchmark Cycle 1 Depletion using MCS

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Introduction

- The MCS code is a Monte Carlo code under development since 2013 at UNIST and designed for the criticality analysis of nuclear reactors with fuel depletion and full thermal-hydraulic (T/H) feedback.
- Advanced methodologies and acceleration techniques have been implemented in MCS including:
  - ✓Whole Core Pin-by-pin Depletion
  - ✓ On-The-Fly Cross Sections Treatment
    - •Multi-poles + Sigma1 + Interpolation s(a,b) + Interpolation p-table
- MCS/FRAPCON Coupling System
  - ✓One-Dimensional Enthalpy Rise Model
  - ✓ Steady-state Fuel Behavior Prediction Model
    - •Gap conductance
    - •Fuel thermal conductivity

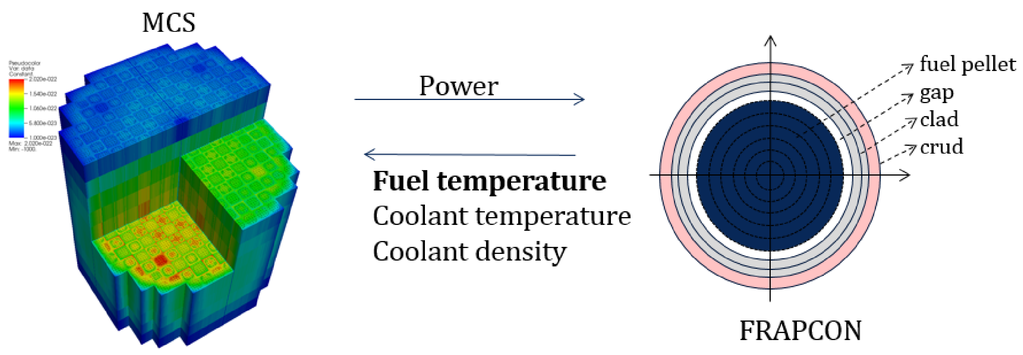

Fig. 1.MCS/FRAPCON Coupling System.

Benchmark Description

- The BEAVRS benchmark (Benchmark for Evaluation And Validation of Reactor Simulations) is an experimental 4-loop Westinghouse PWR benchmark released by the CPRG group at MIT in 2015. The current release is version 2.0.1, which provides the actual core loadings and detector signals from the nuclear power plant for the first two operation cycles.

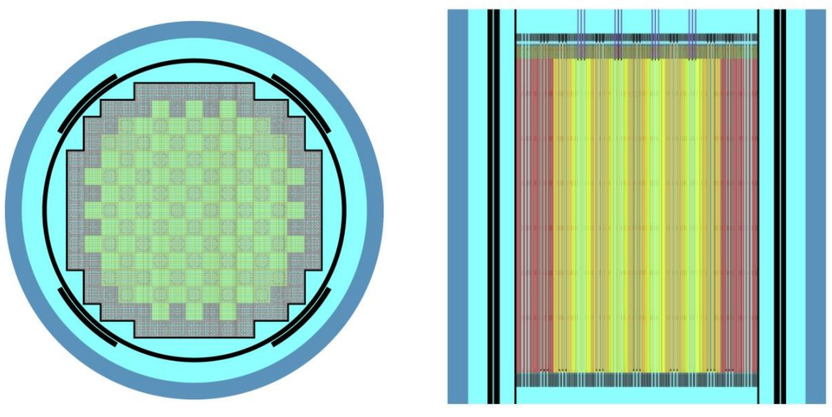

Fig. 2. Top and left view of BEAVRS whole core layout.

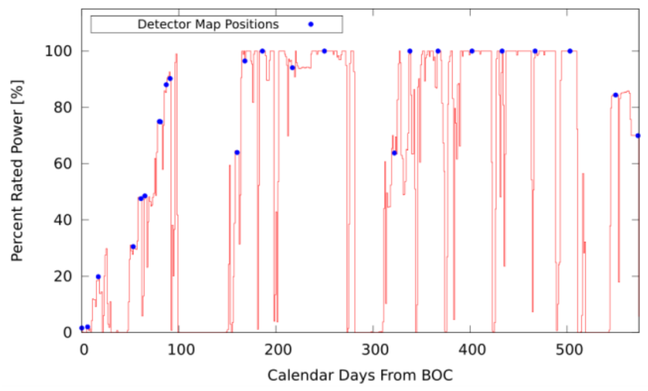

Fig. 3. Power history of BEAVRS whole core model.

Table. 1. T/H Boundary Condition.

Power (%)	100 %
Outlet Pressure (MPa)	15.513
Inlet mass flow rate (kg/s)	17083.33
Inlet Temperature (℃)	292.70
Gap conductance (W/m-K)	10000.0

Simulation Results

- Neutronics Results

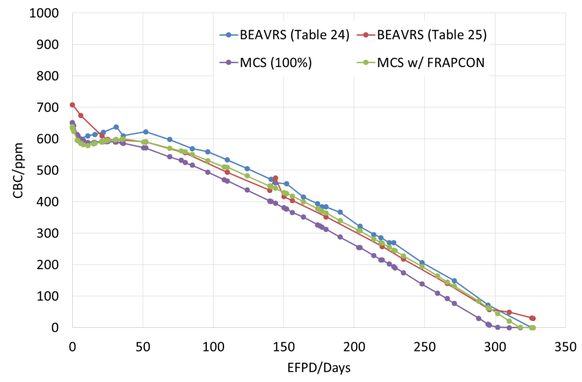

Fig. 5. CBC Letdown Swing with burnup.

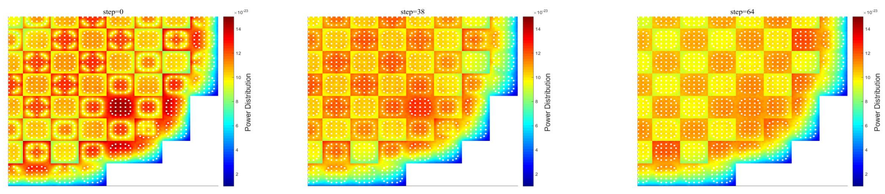

Fig. 6. Power distribution a BOC, MOC, EOC.

- T/H Results

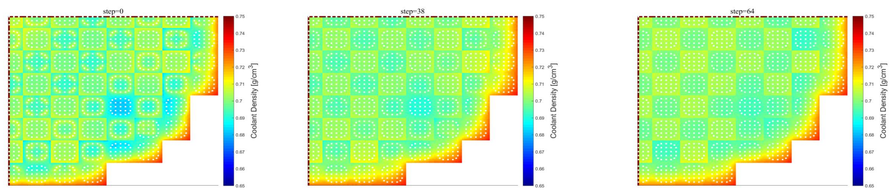

Fig. 7. Coolant density distribution a BOC, MOC, EOC.

- Fuel Performance Results

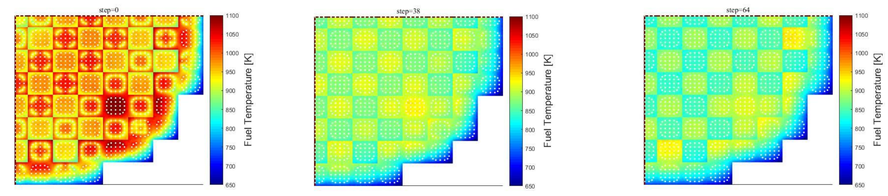

Fig. 8. Fuel temperature distribution a BOC, MOC, EOC.

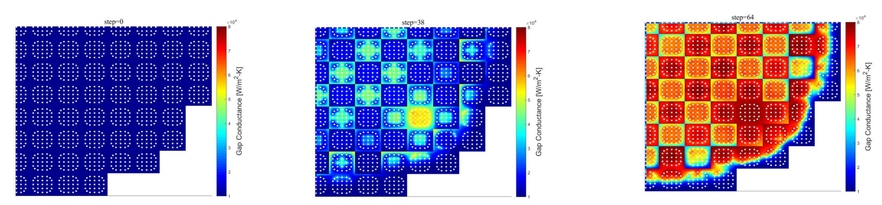

Fig. 9. Gap conductance distribution a BOC, MOC, EOC.

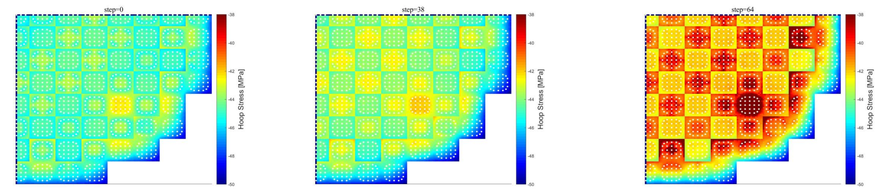

Fig. 9. Hoop stress distribution a BOC, MOC, EOC.

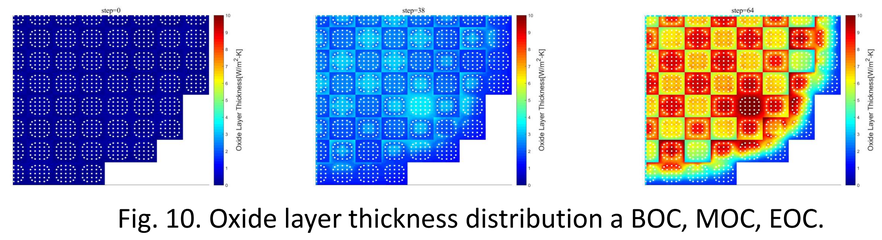

Fig. 10. Oxide layer thickness distribution a BOC, MOC, EOC.

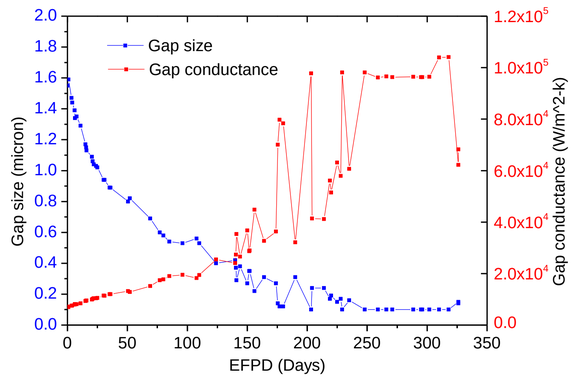

Fig. 11. Gap conductance swing with burnup.

- Conclusions
  - ✓The BEAVRS Benchmark cycle 1 depletion with fuel performance feedback has been performed using MCS/FRAPCON.
  - ✓the CBC letdown was compared with the measured values shown in Table 24 and 25 of the manual, which show a very good agreement between MCS results and measurement.
  - ✓the detailed distributions, such as power density, fuel temperature, coolant temperature and coolant density has been presented in this paper. Furthermore, some unique quantities which can be only simulated by fuel behavior prediction code are illustrated to performance the multi-physics coupling capability of MCS code.