SMR-Core Analysis at pin-level using PARCS-SP3

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SMR-Core Analysis at pin-level using PARCS-SP3

Motivation: Pin-wise TH Feedback
Pin-wise Simulation with “ASSY_TYPE”
Pin-wise XS Optimization

Development: Function Extension of PARCS V331

Verification: Steady State pin-by-pin Simulation for KIT-SMR

Summary and Outlook: Transient Simulation
Implementation to PARCS-ICoCo
Coupling with TH code
Motivation: Pin-wise Simulation, XS Optimization, TH Feedback

The discussion in this slide only concern **Cartesian** geometry

PARCS V331 has two methods for pin-wise results:

- **Nodal + Pin power reconstruction**
  - Advantage: Fast running.
  - Limitation: No Pin-wise TH coupling.
  - Limitation: No Pin-wise XS optimization.

- **FMFD (Fine Mesh Finite Difference)**
  - Advantage: SP3 Pin-wise simulation.
  - Limitation: Use “PLANAR_REG”, no “ASSY_TYPE”.

In KIT, we would like to do:
- Pin-by-pin simulation in core-scale with “ASSY_TYPE”.
- Enable pin-wise XS optimization and TH feedback.

PARCS V331 can not do this
Function extension is required
Development: Function Extension of PARCS V 331

The discussion in this slide only concern Cartesian geometry

For pin-by-pin SP3 simulation with “ASSY_TYPE” activated:
- the most straightforward way is to compose the input files as cases using traditional nodal solvers.
- PARCS V331 has problems dealing with “big data”.

Workflow of PARCS V331:
- Input processing
- Calculation
- Output processing

For example

Memory problems

In GEOM, the problem in
- “RAD_CONF”
- “BANK_CONF”

Function extension:
- 20 files related to input and output processing were modified.
- PARCS V331 now works well with "big data".
Verification: Steady State pin-by-pin Simulation for KIT-SMR

Case Specification – KIT-SMR – assembly configuration:

- Radial configuration
  - 40 radial reflectors
  - 57 fuel assemblies, 6 types, 2 poison types

- Axial configuration
  - P1 – Type A 20 poison rods
  - P2 – Type B 24 poison rods
  - Assembly Type:
    - Assembly Type: 1, 2, 3, 4, 5, 6
    - 1: Active 200 cm
    - 2: 21.5 cm
    - 3: 236.5 cm
    - 4: Burnable Poison Rod: A-20, B-24
    - 5: P1
    - 6: P2
Verification: Steady State pin-by-pin Simulation for KIT-SMR

Case Specification – KIT-SMR – control rod configuration:

Radial configuration
- 6 types

Axial configuration
- AIC – AgInCd
- SS – Stainless Steel
- B4C

Critical configuration
- I – fully inserted
- O – fully withdraw
Verification: Steady State pin-by-pin Simulation for KIT-SMR

Modeling – KIT-SMR – PARCS:

- 6 fuel assembly types: 8 enrichments
- 6 control rod types: 3 absorber materials
- 2 poison rod configurations: 2 materials
- 35 material configurations for fuel assemblies
- 6948 XS definition corresponding to PMAXS files

187x187 pin matrix for:
- Core radial geometry
- Core radial control rod configuration
- Optional – Reflector rotation definition
- 2900 definition of ASSY_TYPE

To be verified:
Pin-by-pin multi-physics coupling system

SERPENT → PARCS → SPH system → Optimized pin-wise XS

\[ 35 \times n\_branch \] inputs

\[ 35 \times n\_branch \] inputs

\[ 35 = \text{number of fuel assemblies} \]

\[ n\_branch = \text{branch number} \]
Verification: Steady State pin-by-pin Simulation for KIT-SMR

First Results – uniform fuel assembly (enrichment 2.0%, no CR):

Axial power distribution

Radial power distribution

Spatial power distribution
Verification: Steady State pin-by-pin Simulation for KIT-SMR

First Results – KIT-SMR – All Rods Out (AIO) – radial relative power distribution:
Verification: Steady State pin-by-pin Simulation for KIT-SMR

First Results – KIT-SMR – All Rods Out (AIO) – spatial relative power distribution:

Original pin-wise XS from Serpent
Verification: Steady State pin-by-pin Simulation for KIT-SMR

First Results – KIT-SMR – All Rods Out (AIO) – spatial relative power distribution:

SPH optimized pin-wise XS
Summary and Outlook

**Motivation 1**
Pin-by-Pin Multi-physics System Parcs-TH

**Development**
20 files related to input and output processing modified

**Problem**
Parcs V331 cannot process “big data”

**Motivation 2**
With ASSY_TYPE enabled

**Motivation 3**
XS Optimization possible

**Pin-by-Pin Parcs Simulation**

**Steady State Verification**
KIT-SMR large data size

**Transient Verification**
KIT-SMR Rod Ejection Accident

**Implementation to PARCS-ICOCO**
Within the McSAFER package

**Pin-by-Pin Coupling with TH code**
SubChanFlow / TwoPorFlow

**Outlook 1**

**Outlook 2**

**Outlook 3**
Questions and Problems

1. PARCS V331 crash due to illegal operation when do the 3\textsuperscript{rd} nodal update:
   - The reflector XS relates to the problem.
   - When the neutron leakage is not significant, PARCS runs well.
   - When the neutron leakage is significant, PARCS crash at the 3\textsuperscript{rd} nodal updating.

2. How to merge two PMAXS files into one single PMAXS file.
   - One file contain the XS data without CR, the other contain the XS with XR.
   - Use GenPMAXS to combine the two PMAXS files?