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Code Package for Reactor Core Design

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Code package for reactor core design consists of nuclear design, thermal-hydraulics design, fuel assembly design and fuel rod design codes to ensure the safety, operability and economical efficiency of the nuclear power plants.

Description

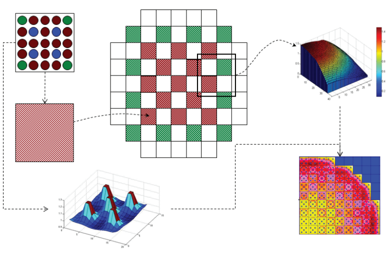
● Background

- Reactor core design codes are softwares to evaluate the neutron, thermal-hydraulics behavior and fuel rod integrity and to generate the relevant safety analysis parameters. They predict the 3-D power distribution of the core to prevent the fuel rod failure during normal operation and generate the data to confirm the safety of the reactor core in the event of an accident.

● Code configuration and features

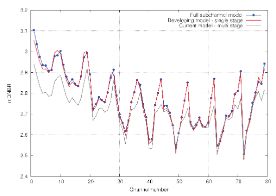
- Major core design codes are KARMA, ASTRA, THALES, ROPER and DYTRAC.
- KARMA, one of the nuclear design code system(KARMA/ASTRA) generates the group constants to be used in ASTRA by adopting the MOC methodology. ASTRA calculates the 3-D power distribution of fuel assemblies and rods for the steady and transient states of the core using SANM and also calculates the adjoint flux to generate the kinetic parameters. The characteristics of KARMA and ASTRA code are as follows:
  - KARMA(Kernel Analyzer by Ray Tracing Method for Fuel Assembly)
    - · Application of MOC (Method Of Characteristics)
    - · Application of CMFD(Coarse Mesh Finite Difference) acceleration method
    - · Power iteration method for eigenvalue problem
    - · Simplified one-dimensional model for reflector group constant
    - · Krylov subspace method using taylor series expansion for depletion calculation
    - · Critical spectrum correction by B1 fundamental mode spectrum calculation

- ASTRA(Advanced Static and Transient Reactor Analyzer)
  - Two or multi-group calculation capability for steady or transient core
  - Adoption of SANM (Semi-Analytical Nodal Method)
  - Accurate simulation of control rod ejection using flux exponential transform



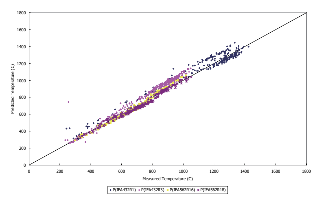
< Homogenization and Reconstruction of KARMA/ASTRA >

- THALES, a thermal- hydraulics design code, is the sub-channel analysis code to analyze the core thermal-hydraulics and confirms the fuel rod integrity by solving the mass, momentum and energy conservation equations on the homogeneous flow field. The characteristics of THALES code are as follows:
  - THALES(Thermal Hydraulic AnaLyzer for Enhanced Simulation of Core)
    - · Sub-cooled boiling and void drift flux model
    - · Stable convergence of core analysis model
    - · Accurate core analysis model
    - · Use of pressure gradient evaluation matrix
    - · PBCGM and Gaussian elimination solver
    - · Water/steam property: ASME, NIST, Simplified water/steam tables



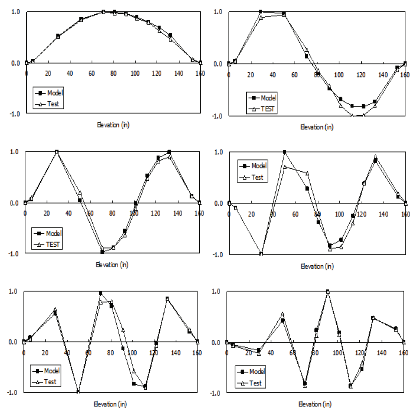
< THALES DNBR Calculation Accuracy >

- ROPER, a fuel rod design code, predicts the neutron irradiation performance to evaluate the fuel rod integrity and analyzes whether the related design criteria are satisfied or not. The characteristics of ROPER code are as follows:
  - ROPER(Fuel ROd PERformance Analysis Code)
    - · Single channel enthalpy rise model
    - · Fuel temperature with finite differential method
    - · Burnup degradation of fuel thermal conductivity
    - · Semi-mechanistic steady-state fission gas release
    - · Clad stress/strain analysis under generalized plain strain condition



< Comparison of Calculated and Measured Fuel Centerline Temperatures >

- DYTRAC is a fuel assembly seismic analysis code to evaluate the fuel assembly integrity during the plant seismic and LOCA using the finite element method. The characteristics of DYTRAC code are as follows:
  - DYTRAC(DYnamic TRansient Analysis Code)
    - · Fuel assembly detail analysis
    - · Beam-spring-mass simplified fuel assembly model
    - · Optimization design algorithm for the generation of simplified fuel assembly model
    - · Newmark-beta time integration for dynamic analysis
    - · Same simplified model for mixed core analysis



< DYTRAC Simplified Model Verification on Fuel Assembly Dynamic Characteristics >

Distinctiveness

- Each code adopts the latest methodology for the core design and analysis, and equipped with design procedure simplifying function.
- The simplified design procedure and the code user convenience decreased human errors.

Experience

- Reload core design for SKN 3 Cycle 2
- Initial core design for SKN 5 & 6
- Technology transfer to the UAE
- OPR1000 HIPER RTSR design

Deliverables

- Code system of each design area
- Training and manual of nuclear core design technology
- Continuous code maintenance

Technology Readiness Level (TRL)

Actual system proven through operation

Business Model

Technology Transfer

Licensing

Joint Search

Service Execution

Others