WORKSHOP ON CALCULATION OF BWR FUEL ISOTOPIC COMPOSITION

UPM activities:
- Neutronic/Thermohyduralic (COBRA-TF) coupling
- Inventory prediction using SCALE6.1

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Goal

Tool to couple neutronic and thermal-hydraulic calculations in order to perform BWR burnup analysis

- TH 3D calculations
- N 2D calculations
- Depletion 2D calculations
- Axial power distribution determined by the core design analysis

Improve BWR isotopic evolution and/or distribution; reduce differences between simulation results and experimental data
Calculation model

Based on paper: “Effect of Subchannel Void Fraction Distribution on Lattice Physics Parameters for Boiling Water Reactor Fuel Bundles” (Ikehara et al.)

- Axial power distribution determined by the core design analysis: $P_{a;k}$
- When N-TH iteration finished $\rightarrow V_{f;k} \approx $cte during depletion
Neutronic 2D calculation **NEWT**
Depletion 2D calculation **TRITON**
Isotopic calculation **ORIGEN-S**

- NEWT and TRITON calculations at each of the 25 nodes are performed in parallel

↓ ↓ ↓ computation time

- Parallel programming software: **MPI**
  - Macros and functions library
**TH 3D calculation Subchannel analysis codes**

- Detailed model of the subchannels geometry within the fuel assembly
- Can predict radial void distribution at each axial level
- Codes used:
  - COBRA-EN
  - COBRA-TF
- **COBRA-EN**: Three equations model, mixture
  - Good results at very low void fractions
  - Easy geometry definition
  - Drawbacks:
    - Unable to define different geometry sections: vanishing and dominating
    - Correlation for void fraction: poor results when void fraction becomes significant

- **COBRA-TF**: nine equations model, two-fluids, three fields
  - Complete separation of vapor and liquid
  - Can predict with higher accuracy annular flow regime at high void fraction
  - High flexibility of geometry definition including different axial sections
  - Drawback:
    - Complex definition of geometry
    - Long calculation time, short compared with NEWT
Considerations

- Subchannel code should predict **average radial void fraction** for each axial node given at the benchmark specifications.
- There are two sections included in the assembly with distinctive geometric definition.

  - Conventional subchannel geometry with water holes.
Considerations

- Subchannel code should predict **average radial void fraction** for each axial node given at the benchmark specifications.
- There are two sections included in the assembly with distinctive geometric definition:
  - Non-conventional subchannel geometry:
    - Partial power rods
    - Exotic subchannel shapes
Considerations

- COBRA-EN unable to simulate directly partial rods
  - Two steps calculations were defined:
    - Dom (inferior) last axial level variables distributions are used as boundary conditions for van (superior) section

- COBRA-TF can define two sections
  - Due to the complex definition of the model, first results were obtained with one section (dom) for the whole assembly
  - Two sections model is already working although results were not yet analyzed
Average radial void fraction comparison

68.6 % nominal power

Axial position (m)

Average void fraction (%)
Average radial void fraction comparison

86.6 % nominal power
Average radial void fraction comparison

109.3% nominal power

Average void fraction (%) vs. Axial level (m)

- COBRA-EN LEVY
- DISEÑO 109.3
- CTF
Differences with data

Void fraction averaged differences with data

<table>
<thead>
<tr>
<th>Void fraction differences (%)</th>
<th>CTF</th>
<th>COBRA-EN LEVY</th>
<th>COBRA-EN EPRI</th>
<th>COBRA-EN HOM</th>
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CTF
COBRA-EN LEVY
COBRA-EN EPRI
COBRA-EN HOM
Void distribution at 1.35m axial level (CTF 86.6%)
Conclusions and ongoing work

- **Conclusions**
  - Coupled N-TH tool on development can use COBRA-TF as TH code for radial void distribution

- **Ongoing work**
  - COBRA-TF integration in the coupled tool
  - Parallel NEWT calculation at the 25 nodes defined in the specifications