The OSCAR code: an unique tool for simulating reactor contamination

Le code OSCAR : un outil unique de simulation de la contamination en réacteur

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Outline

- OSCAR Context and Overview
- OSCAR Simulation and GUIs
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Industrial issues

• **Radioprotection**: Reduction of Occupational Radiation Exposure (ORE)
• **Environment**: Minimization of release/waste – Optimization of dismantling process – Source term in case of incident/accident
• **Availability**: Optimization of reactor operation
Simulation of contamination transfer in nuclear reactor systems during power operation and during cold shutdown (PWR: 20→350 °C - reducing/oxidizing - acid/alkaline)

- Calculation of masses and activities of Corrosion Products/Coolant activation products/ Fission Products/Actinides in solid, liquid and gaseous phases of nuclear circuits as a function of time (normal operation over several decades and transients over several minutes/hours)

- Development of a calculation code by CEA in collaboration with EDF and FRAMATOME

  **OSCAR** (Outil de Simulation de la Contamination en Réacteur)
  (First version in 2008 OSCAR = merge of PACTOLE and PROFIP developed since 70’s)

- **OSCAR** originally developed for PWR
  Modular code (easy evolving tool)
  Validation based on a large OPEX unique in the world (~400 EMECC campaigns since 70’s)
  Current version: OSCAR V1.4 released in 2017

- Application to **Fusion reactor**: OSCAR-Fusion

- Application to **SFR**: OSCAR-Na
OSCAR V1.4

- Linux OS
  - Debian Jessie V8 64 bits
  - RedHat Santiago V6 64 bits

- SALOME 7
  - Python 2
  - Qt 4

→ SALOME 9
  - Python 3
  - Qt 5

Test phase

OSCAR Context and Overview

Overview of the OSCAR package
Circuits discretized in control volumes according to:
- material
- geometry
- thermal-hydraulics
- neutronics
- operation

Up to 6 media in each control volume

HL/COL/CL: Hot/CrossOver/Cold Leg
SG: Steam Generator
CVCS: Chemical and Volume Control System
Isotopes of these elements

- CPs: Ni, Co, Fe, Mn, Cr, Zn, Ag, Sb, Zr, Cu
- FPs: Xe, Kr, I, Cs, Sr
- Actinides: U, Pu, Np, Am, Cm...
- N, Ar

Radioactive half-lifes: from second to million years

Unsteady mass balance equation for each isotope in each medium of each region

\[
\frac{\partial m_i}{\partial t} = \sum_{\text{Source}} J_m - \sum_{\text{Sink}} J_m
\]

- \( m_i \): mass of isotope \( i \) in a medium
- \( J_m \): mass rate between 2 media or 2 isotopes or 2 regions
OSCAR Context and Overview

OSCAR Modelling: Transfer mechanisms

Corrosion Products

Fission Products and actinides
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OSCAR Simulation and GUIs

OSCAR Input/Output GUIs

- Input data file (.xml)
  - Geometry
  - Thermal-hydraulics
  - Materials
  - Neutronics
  - Operating data

  - **Input GUI (SALOME)**

- Output files (.csv)
  - Masses
  - Activities
  - Dose rates
  - Mass rates
  - Chemical data
  - Thermal-hydraulics data
  - Region characteristics
  - Operating data

  - **Output GUI (SALOME)**
OSCAR Simulation and GUIs

OSCAR Simulation of real PWR case

- First 15 cycles of an EDF 900 MWe unit - Steam Generator Replacement during cycle 8 shutdown (SG tubing 600MA → 690TT)
- OSCAR Input GUI: Operating data import from Excel files + Possibility of data smoothing

OSCAR run duration ≈ 15 h on a standard Linux PC
Good agreement between calculation and measurements

- Surface activities calculated by OSCAR close to EMECC measurements
- Calculated variations consistent with operational experience
- **CurvePlot** (SALOME 7)
  - Need for improvements:
    - Rename curve label
    - Choose axes graduations
    - Same order for Plot browser and tabs
    - ...

- Regression compared with Visu (SALOME 5)
  - Final figures using Excel (.csv files generated by output GUI)

- Development of **IVS** (Python) in OSCAR output GUI (Interface de Visualisation Synoptique)
OSCAR Simulation and GUIs

OSCAR Output GUI - IVS
Thank you for your attention