CATHARE 2 V2.5_2:
a unique version for various applications

Focus on « CATHARE-Na »

Discussion on « CATHARE-Pb »

CATHARE 2 V2.5_2:
a single version for various applications

Context

Various concepts to be studied

- **Generation IV** (Gas Fast Reactors, Very High Thermal Reactor + H2, Supercritical Light Water Reactor, Sodium Fast Reactor)
- **Experimental reactors** : JHR, CABRI, OSIRIS
- **Nuclear propulsion**
- Non-nuclear industrial applications: **cryogenic rocket engines**

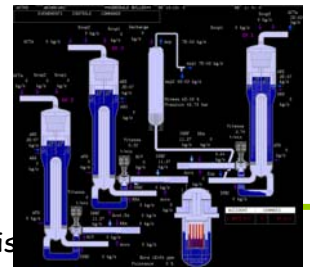
Need of a system code to perform exploratory TH simulations

- Describe the thermal hydraulics of the whole plant, primary and secondary circuits
- Design and optimisation of systems
- Incidents and accidents analyses for plant safety evaluation

Extension of CATHARE 2 capabilities to other concepts than LWRs

V2.5 — 2003

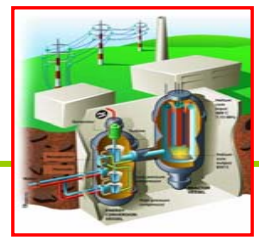
SCAR simulator



V2.5_1 — 2005

Containment modelling

Gas Cooled Reactors

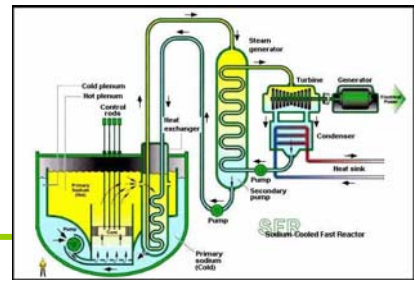


V2.5_2 — 2008

Multi-purpose multi-reactor concept version

GenIV: GCR,SFR, SCWR

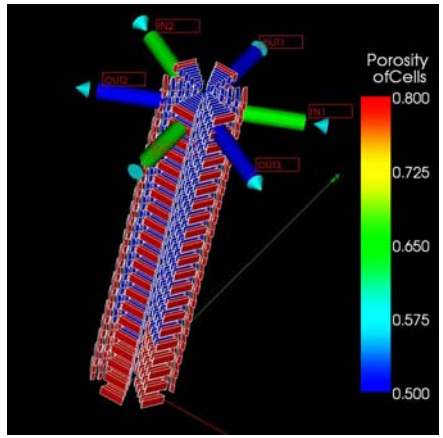
Cryogenic fluids



V2.5_2 a multi-purpose multi-reactor concept version

One **unique** code version for all the applications

- New capabilities integrated as independent options
  - *Ex: option « single-phase »*
- Benefit from a maximum reusability
  - *numerical reliability, existing basic modeling features well consolidated, GUITHARE…*
- Minimize development and maintenance costs
  - *Minor modifications of existing capabilities and addition of some new features for each application*
  - *Unique team for maintenance and user support*
- Same stringent procedures for quality assurance
  - *Non regression tests, portability tests, extensive documentation*



CATHARE 2 adaptation and development

A **generic** development methodology

- List the common methods and functionalities
  → a common thermal hydraulic kernel to be shared

- List the functionalities specifically devoted to one particular application
  → *can be shared*
  → *can be stored in private libraries (to insure the confidentiality)*

The major differences between the applications:
- fluid and closure laws
- components and correlations

CATHARE 2 adaptation and development

Extension to other fluids

- By default, the main fluid is **WATER**
  - two-phase flow, liquid and gas phases
  - possible presence of Non Condensable gases

- For Gas Cooled Reactor applications:

  main fluid = water; liquid phase = residual phase;

  gas phase = **Helium or mixture He/Nitrogen** treated as NC

→ Efforts on physical correlations. Ex: improved gas mixture properties

→ Efforts on numerical performances : Ex "single-phase" option

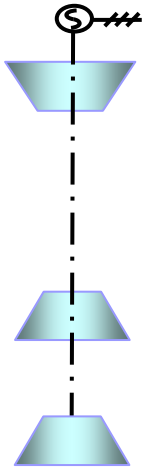
- For other applications:

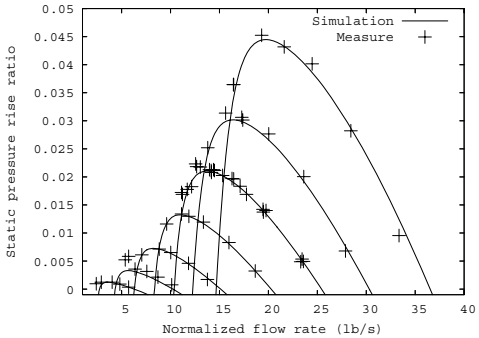
  Possibility to **choose an other fluid** by circuit: **Sodium, Supercritical water (IAPWS tables), H2,…**

→ thermodynamics properties and associated closure laws implemented in specific libraries

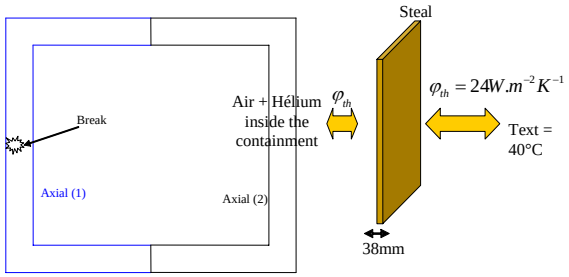
CATHARE 2 adaptation and development

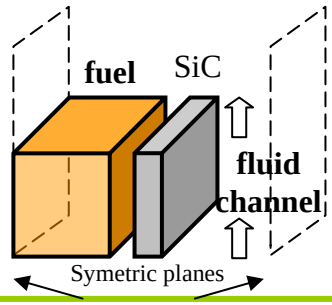
Specific components and correlations

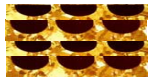


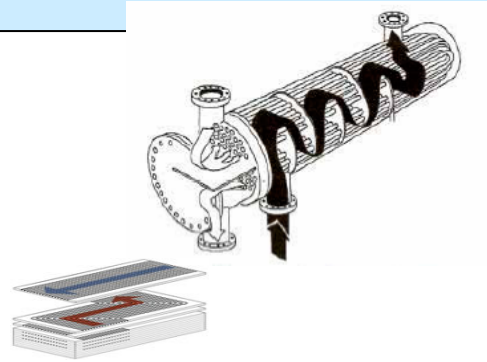


- 0D turbomachinery module (circulator axial and radial type, turbine, shaft, generator)
- Electro-magnetic pump model
- Neutron kinetics feedback model specific for each concept
- Physical correlations (gas properties, gas mixture, specific components correlations (HX)…)
- …



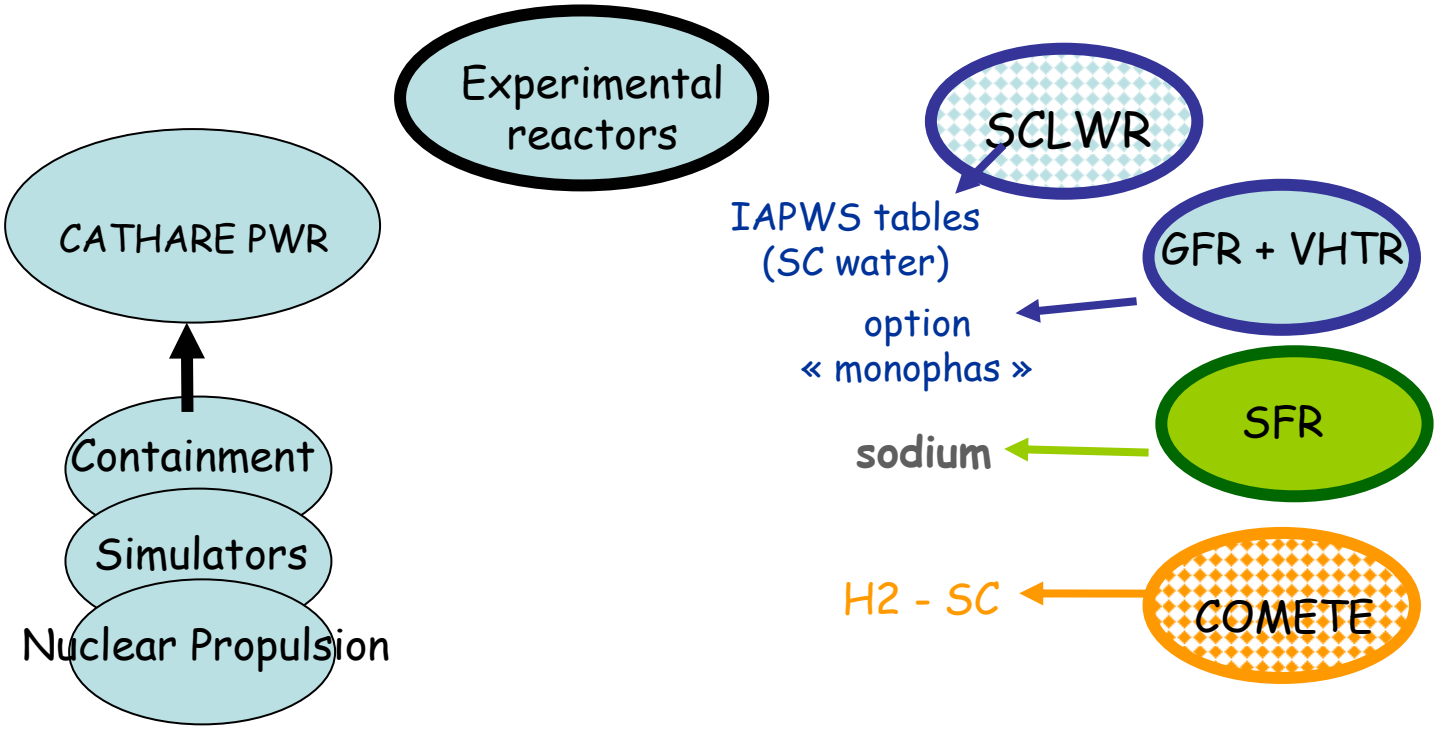






CATHARE V2.5_2 release

A unique code version



but customized deliveries

development of an automatic release procedure to select « private » libraries according to access rights

Fluid libraries, Specific correlations, Libraries for pump and TM characteristics

Focus on CATHARE « Na »

CATHARE « Na »: the timing

- OASIS: system code used in the past for sodium calculations

- phase 1 **(2005-2006)**

  First developments and feasibility calculations (comparison with OASIS on SMFR calculations)

  - *Implementation of the thermodynamical properties and physical correlations*
  - *Adaptation of the kinetics and fuel models*
  - *First CATHARE modeling of SMFR reactor and comparison calculations with OASIS:*
    - *Loss of external and internal pumps (ULOF)*
    - *Power transient (UTOP)*

- phase 2 **(2007)**

  Additional developments and validation calculations

  - *1st modeling of SPX1: 1st feasibility calculation (SCRAM)*
  - *Release of a 1rst CATHARE-Na version*

- phase 3 **(2008…**

  adaptation and use of CATHARE for innovative SFR designs

CATHARE « Na »: the developments

- Sodium thermodynamic and transport properties

- Physical laws :

  wall heat transfers, pressure losses in the core.

- 2 simplified models of Electro Magnetic pumps:

  proportional model, linear model with induction

- Modeling of specific feedback reactivities:

  Differential thermal expansion of core vessel and internals, control rods mechanism thermal expansion, change in the compacity of the core related to contact pads…

- Improvement of CATHARE2 efficiency :
  - Numerical reliability
  - Non condensable gases treatment

- New needs (models, components, …) ?

Discussions on « CATHARE-Lead »

Steps towards CATHARE « Pb »

Introduce a new fluid

Thermodynamic properties of liquid Pb (Pb-Bi?)

- λ, Cp, μ
- ρ

- Availability?
- In which form? Analytical function? Tables?
- Which dependency? (in CATHARE H et P)

Physical laws (C_f, Nu)

- Are the physical laws suitable for Lead (by default water's laws)?

Vapor phase to be taken into account

- Boiling T°= 1750°C → low risk
- Nevertheless need to take into account this phase in CATHARE

⇓

Possibility to develop a « one-phase » option?

(the 3 « unnecessary » equations are simplified)

Steps towards CATHARE « Pb »

Identify the needed developments

May depend on:

- the reference concept
- the transients to be analyzed

- new components?

Ex: pump-SG integrated

- What are the major physical phenomena?

Ex: natural convection to remove decay heat

Make sure of the numerical reliability

Identify needs of validation

Code to code benchmarks

Comparison against experimental data

- physical correlations
- component modeling
- system effects

to be discussed

- the structure « new fluid » exists in CATHARE 2 → ++

•Is there any system code available to "retrieve" the know-how ? Or to make some benchmark?

What about availability of experimental data on lead? Available for CATHARE-Pb validation?

•What are the timing constraints?