Application of CFX code in Nuclear Reactor Thermal Hydraulics at the Brazilian Nuclear Technology Development Center (CDTN)

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PRESENTATION TOPICS

• Overview of CDTN;

• Recent Research;
  – Thermal Stratification
  – Perforated Plates and the Lower end Nozzle
  – Spacer Grids
  – Countercurrent Flow Limitation

• Final Remarks;
OVERVIEW OF CDTN

Brazilian Nuclear Technology Development Center (CDTN – Centro de Desenvolvimento da Tecnologia Nuclear)
Global view of Brazilian Nuclear Energy

Federal Government

Science and Technology Ministry
- National Nuclear Energy Commission (CNEN)
  - Research and Development Directory
  - Radioactive Protection and Safety Directory
    - CRCN
    - IEN
    - IRD
    - IPEN
    - CDTN

Defense Ministry
- INB
  - Mining and production of nuclear fuel

Energy and Mines Ministry
- ELETRONUCLEAR
  - Angra I and II Nuclear Reactors

Energy and Mines Ministry
- Rio de Janeiro
- Angra dos Reis - Rio

Science and Technology Ministry
- Technology Center of the Navy in São Paulo
- Rio de Janeiro
- Angra dos Reis - Rio

R&D institutes of CNEN
- Recife
- Rio
- São Paulo
- Belo Horizonte

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Brazilian Nuclear Technology Development Center
Description of the Brazilian Nuclear Technology Development Center (CDTN)

- Considered as a large institute, CDTN occupies an area of 240,000 m², being 35,000 m² of constructed area.

- Possesses a research nuclear reactor (TRIGA), radiation installations (Gama irradiation Laboratory and Radiopharmaceuticals research and production unit) and a total of 50 laboratories for diverse applications.

- CDTN acts in the nuclear field performing Research, Technological Development and Postgraduate education;
The Work Force of CDTN

Total Work force 622

Permanent Employees 387
  - 89 Doctors
  - 70 Masters
  - 227 Specialists

Complementary Staff 226
  - Collaborators;
  - Students;
  - Cleaning and conservation;
  - Security;
  - Nursery;
  ...
Main Fields of Research at CDTN

• Health
  – Medical application of radiations;

• Nanotechnology
  – Development of new materials, products and processes;

• Industry
  – Production of Radiopharmaceuticals;

• Environment
  – Waste management;
  – Mineral Technology;
  – Impact assessment;

• Nuclear Technology
  – Fuel Technology;
  – Reactor Technology;
    • Thermal hydraulics
    • Neutronics
    • Accident analysis
  – Structural Integrity;
  – Analytic Techniques;
Thermal Hydraulics Laboratory of CDTN
Thermal Hydraulics Laboratory of CDTN

• The laboratory’s objective is to investigate experimentally and numerically single and two phase flow in geometries and conditions of nuclear systems and components.

• These studies intend to increase the knowledge of the behavior of the flow, assisting in the further development of nuclear reactor technology and in academic research in the field of nuclear thermal-fluid dynamics.
RECENT RESEARCH

Studies performed over the past six years applying ANSYS
THERMAL STRATIFICATION

Experiments, CFD and Mechanical Simulations

Products: 1 Doctoral theses (Experimental / Mechanical), 1 Doctoral theses (Experimental / CFD in progress) and 8 Graduation Students Scientific Initiations
Thermal Stratification
Thermal Stratification: CFD Simulation

Mesh
874,586 nodes
3,699,499 elements
Thermal Stratification: Stress analysis
Thermal Stratification: Stress analysis
PERFORATED PLATES AND THE LOWER END NOZZLE

Experiments and CFD Simulations

Products: 1 Doctoral theses (Experimental / CFD in progress), 1 Masters theses (Experimental / CFD), and 5 Graduation Students Scientific Initiations
Lower End Nozzle

Nuclear Fuel Element (NFE)

Numerical Simulation of the Lower End Nozzle of the NFE
Lower End Nozzle

\[
P / P_{ref}
\]

- Nozzle
- Perforated plate

\[
Re = 111847
\]
\[
Re = 337263
\]
\[
Re = 565109
\]
\[
Re = 773724
\]

- \(k-\varepsilon\)
- S.S.T.
- Experimental
Perforated Plates: Experiments

Experimental assembly

Pressure taps
Perforated Plates: CFD Simulation

![Image of velocity and pressure drop simulations with data points and graph showing pressure drop over length for Plate 07.]
SPACER GRIDS

Experiments and CFD Simulations

Products: 1 Doctoral theses (Experimental / CFD in progress) and 2 Graduation Students Scientific Initiations
Spacer Grids
Spacer Grid
COUNTERCURRENT FLOW LIMITATION (CCFL)

Experiments and initial CFD Simulation

Product: 1 Doctoral theses (Experimental) and 1 Graduation Students Scientific Initiations
Countercurrent Flow Limitation (CCFL)

Vapor/Water interface shear and drag causes resistance to water flow, lowering the net water flow rate into the core.
Countercurrent Flow Limitation (CCFL)

Experimental model

CFD Model

Preliminary Simulation

Volume Fraction of Water

0.00 0.25 0.50 0.75 1.00
FINAL REMARKS
Final Remarks

- ANSYS codes have been applied with success at CDTN, with more than 20 academic papers and 5 theses were developed.

- The V&V studies performed over the past years show very satisfactory results with ANSYS CFX code.

- It must be highlighted that experiments and numerical simulations are both indispensable for proper scientific and technological work.
THANK YOU

Questions?