Simulation of Flow Behavior in the HANARO Reactor Pool by Using the MARS Code

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Outline

- Introduction
- Flow behaviours in the HANARO pool
  - Measurements
  - CFD analysis
- Simulation of the HANARO pool by MARS code
- Concluding remarks

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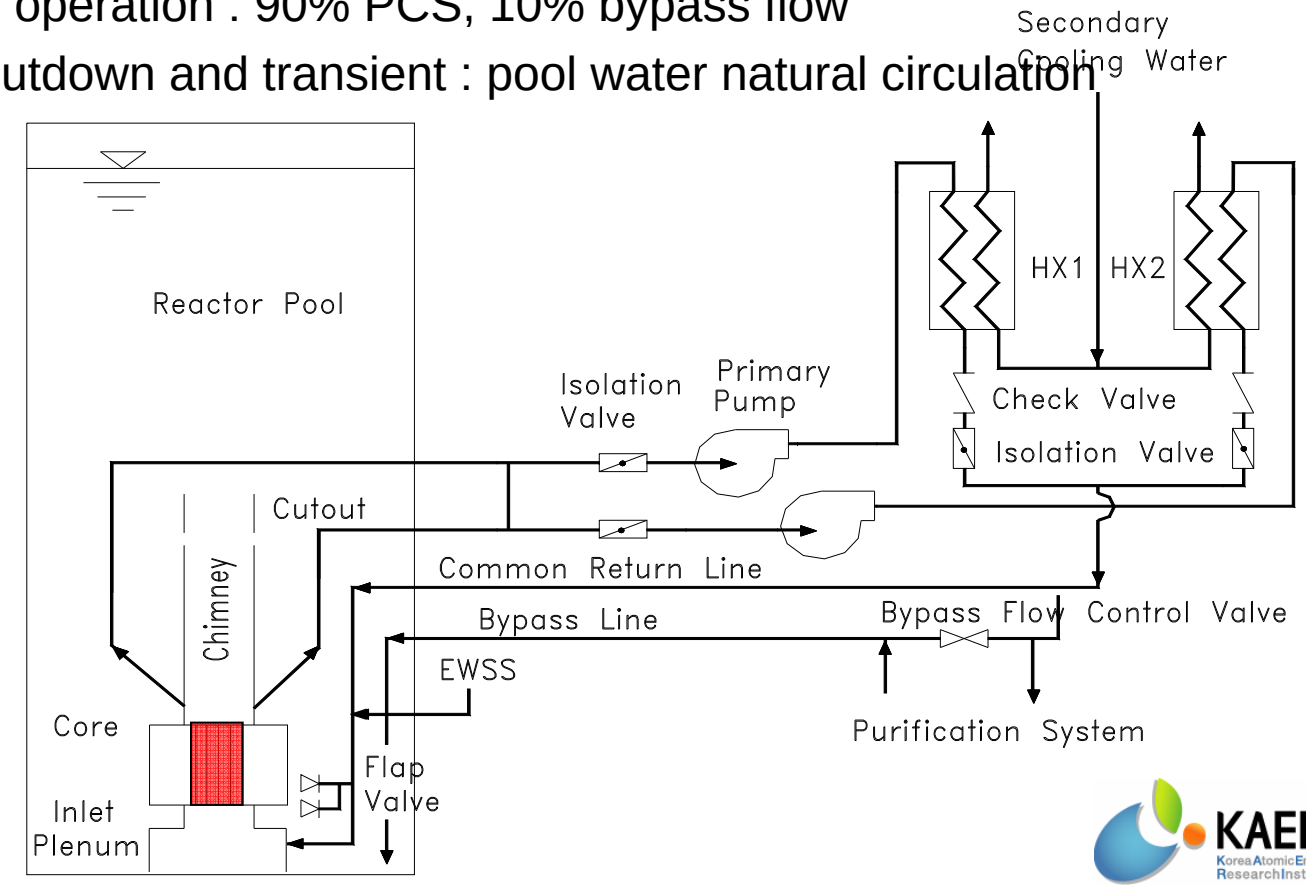
Introduction (1/3)

PCS of the HANARO

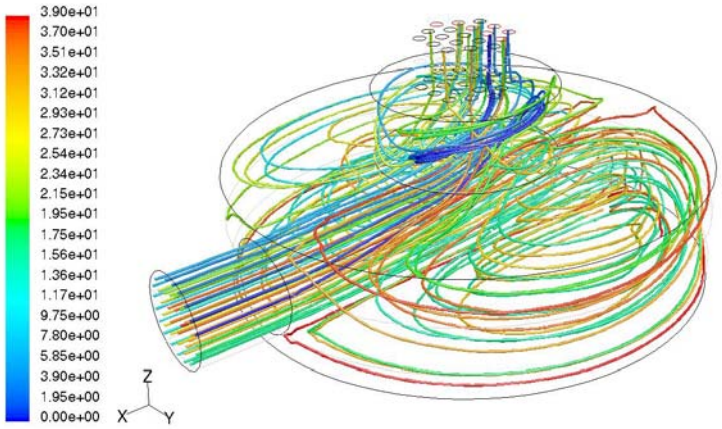
- Open-tank-in-pool type RR with 30MWth
- Upward forced convection cooling system
  - At normal operation : 90% PCS, 10% bypass flow
  - During shutdown and transient : pool water natural circulation

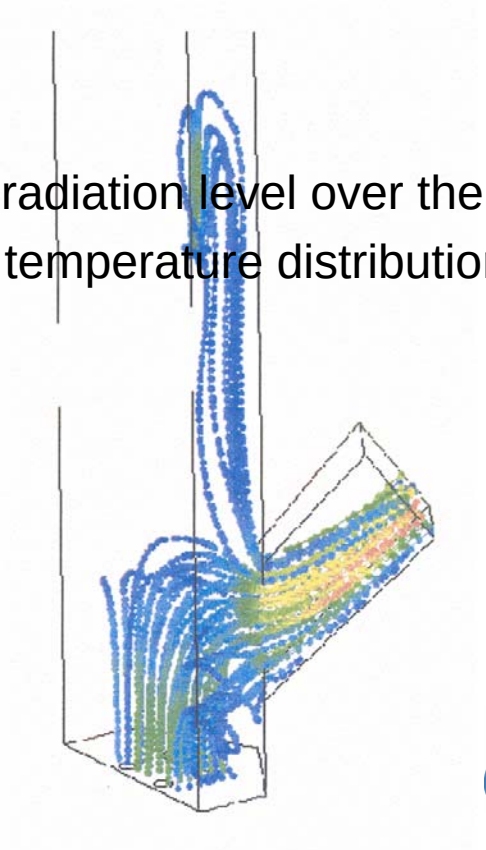


Introduction (2/3)

❑ Concerned areas for 3D flow behaviors in HANARO

- ❖ Inlet Plenum
  - ◆ Generation of vortex → a possible cause of fuel wearing
- ❖ Chimney
  - ◆ Suppression of upward core flow
- ❖ Reactor pool
  - ◆ Behavior of bypass flow in the pool → radiation level over the pool top
    temperature distribution in Rx pool





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Introduction (3/3)

Multi-Dimensional T/H System Analysis Code, MARS

- Unification of RELAP5 (1D Module) and COBRA-TF (3D Module)
  - Multi-Dimensional TH Analysis Capability
- Coupled calculation capabilities
  - Three-Dimensional Reactor Kinetics Code, MASTER
  - Containment Analysis Code, CONTEMPT4 and CONTAIN

Objective

- To simulate the HANARO reactor pool by MARS code from the viewpoint of practical operation and safety

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Flow behaviors in the HANARO pool (1/5)

❑ Estimation from measurements

❖ In commissioning test,

- ◆ Core jet is suppressed by the bypass flow with > 5% of PCS flow
- ◆ Radiation level at near pool surface : Measured > Calculated

  → One of reasons is bypass flow.
- ◆ Installation of a hot water layer (HWL) system

❖ Temperature and Na-24 Activity distributions in the pool

- ◆ 3 regions with different temperature
- ◆ Distribution of Na-24 activity

⇒

- ➢ **Most of bypass flow is sucked into the chimney at near chimney top.**
- ➢ **Mixing the hotter water in HWL and the cooler pool water**
- ➢ **Asymmetric flow below 6 m**

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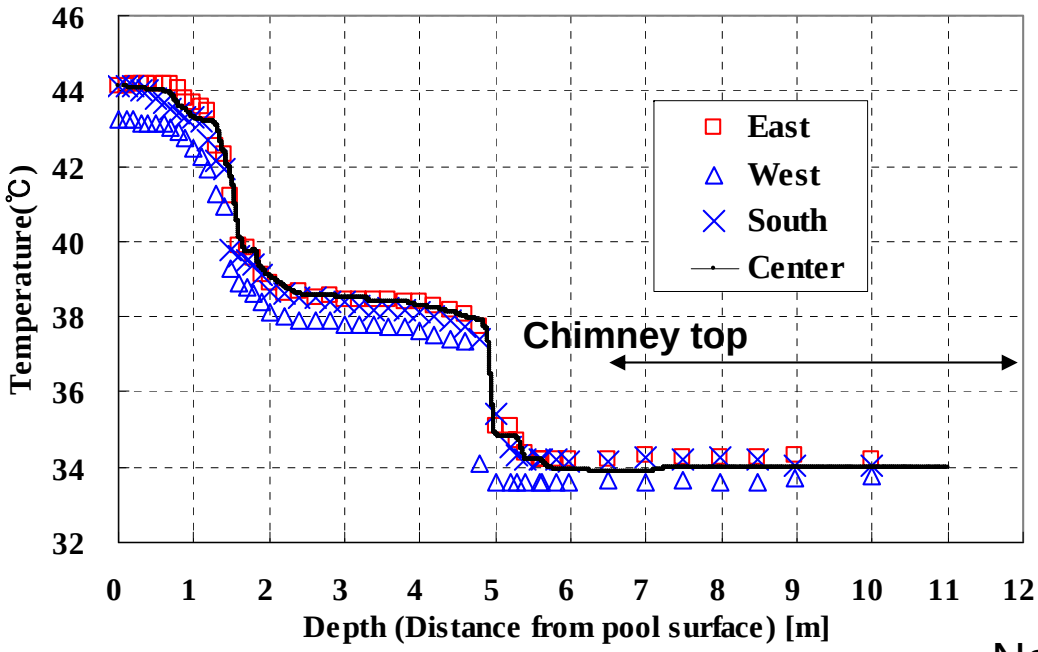
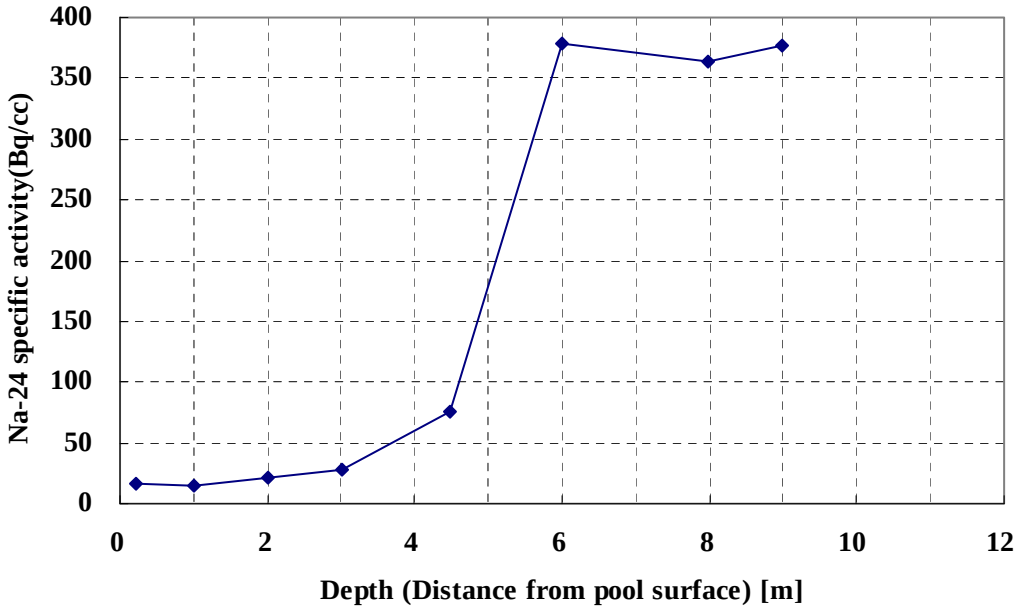
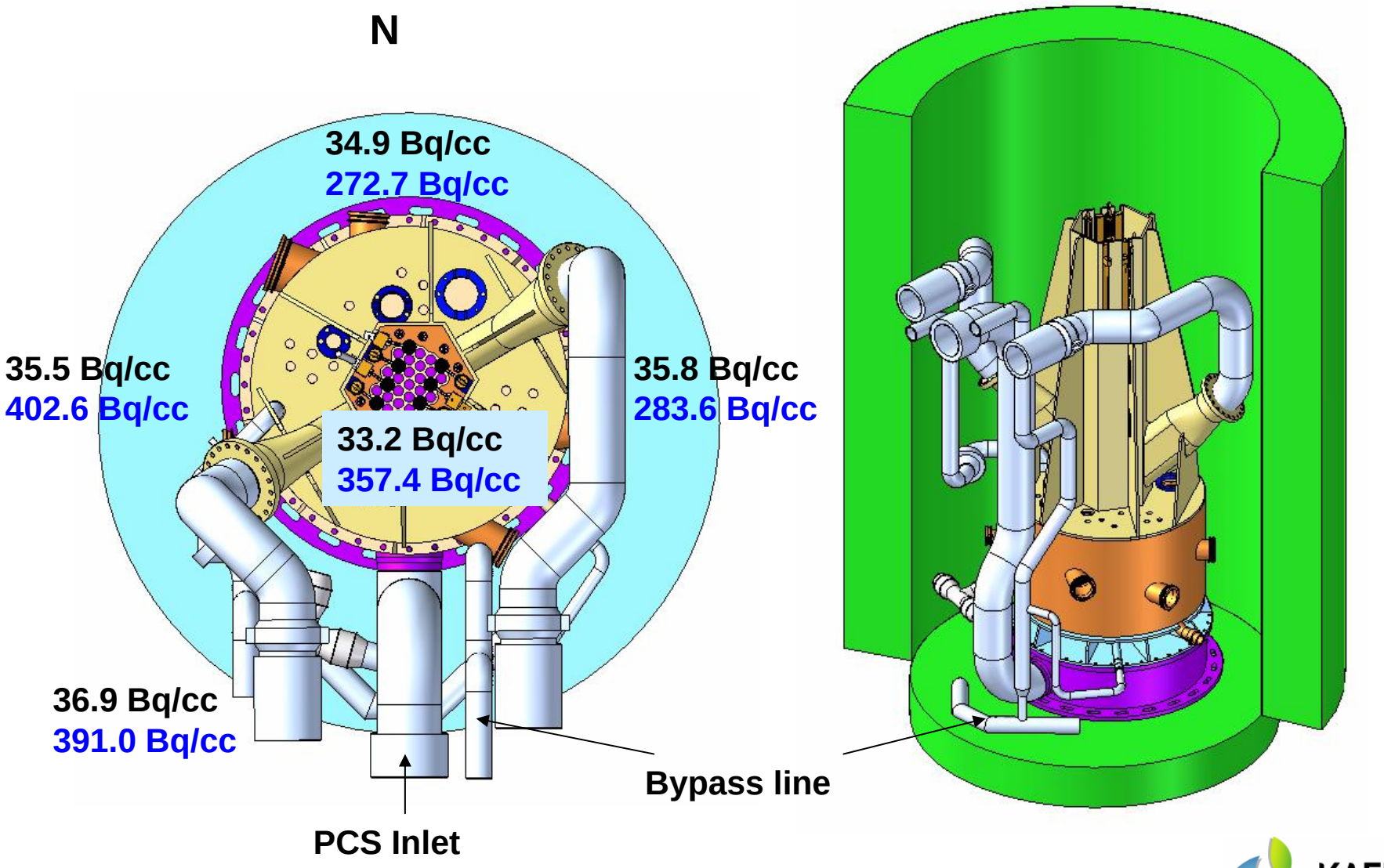
Temperature distribution in the reactor pool



Na-24 distribution in the reactor pool



Flow behaviors in the HANARO pool (3/5)



Flow behaviors in the HANARO pool (4/5)

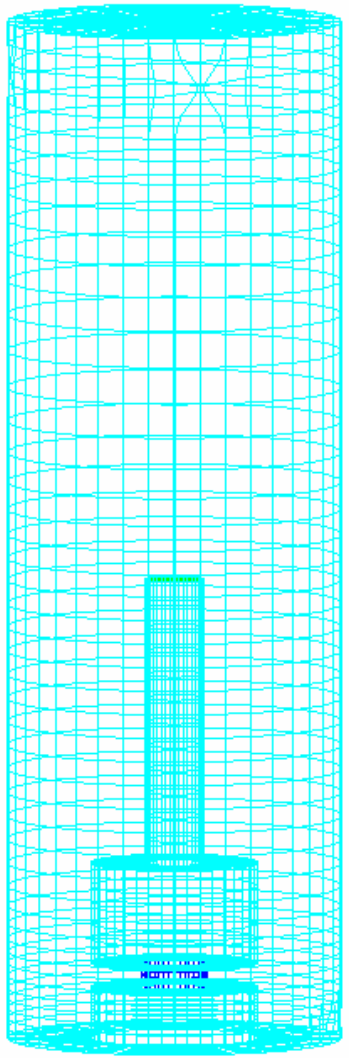
❑ CFX simulation

❖ Modeling

- ◆ Cell number : 17,620 & 28,600
- ◆ Flow split : 1 vs 1.5
- ◆ How water layer : 45℃

❖ Results

- ◆ Most of bypass flow are sucked into the chimney.
- ◆ But, a part rises upwards to the pool surface, forming a counter clockwise outer circulating flow.
- ◆ Show similar temp. distribution with the measurement
- ◆ HWL is well maintained if the .



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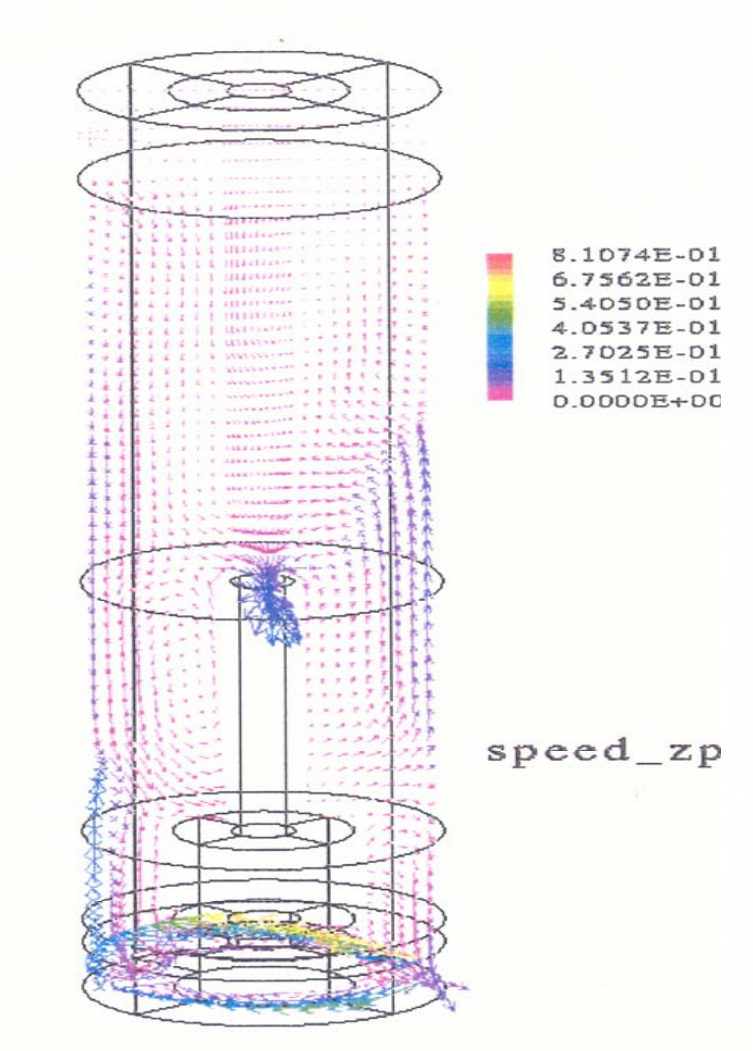
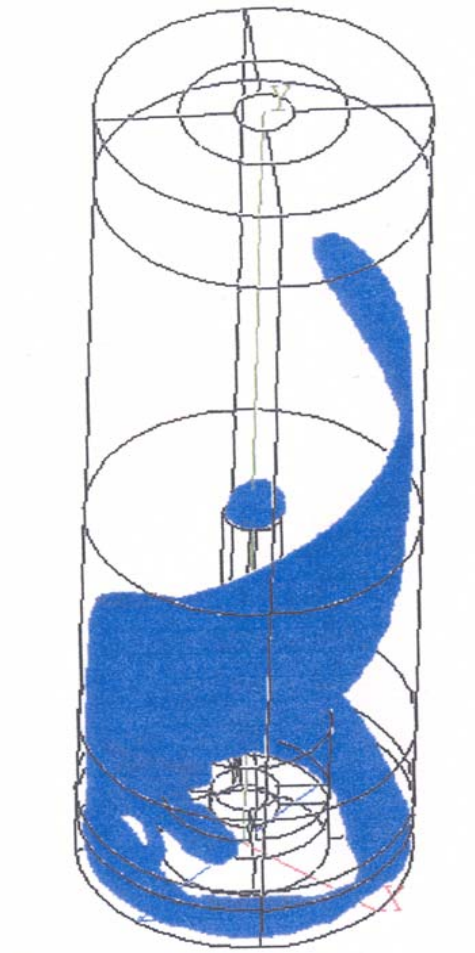
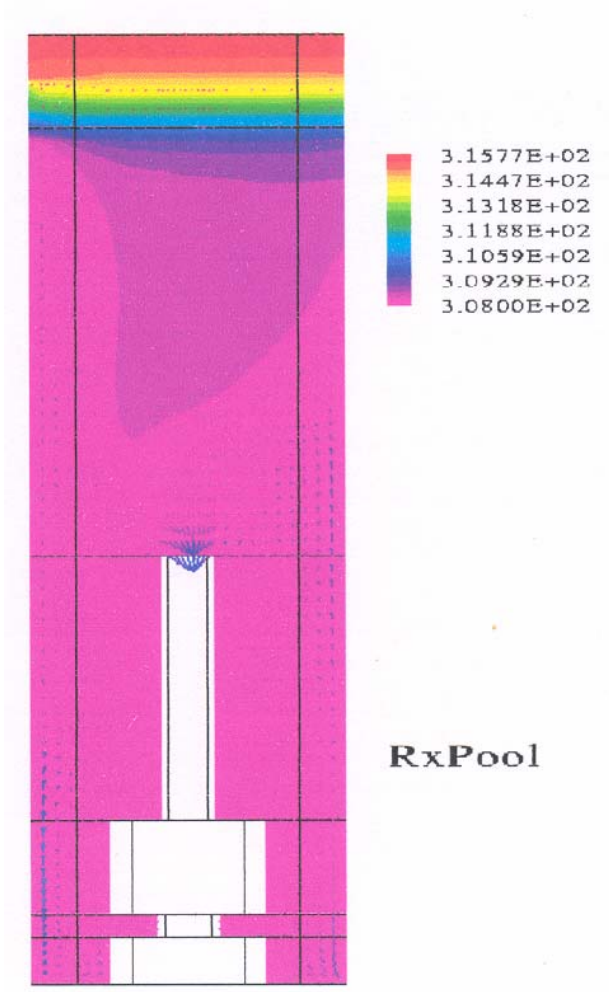
Flow behaviors in the HANARO pool (5/5)







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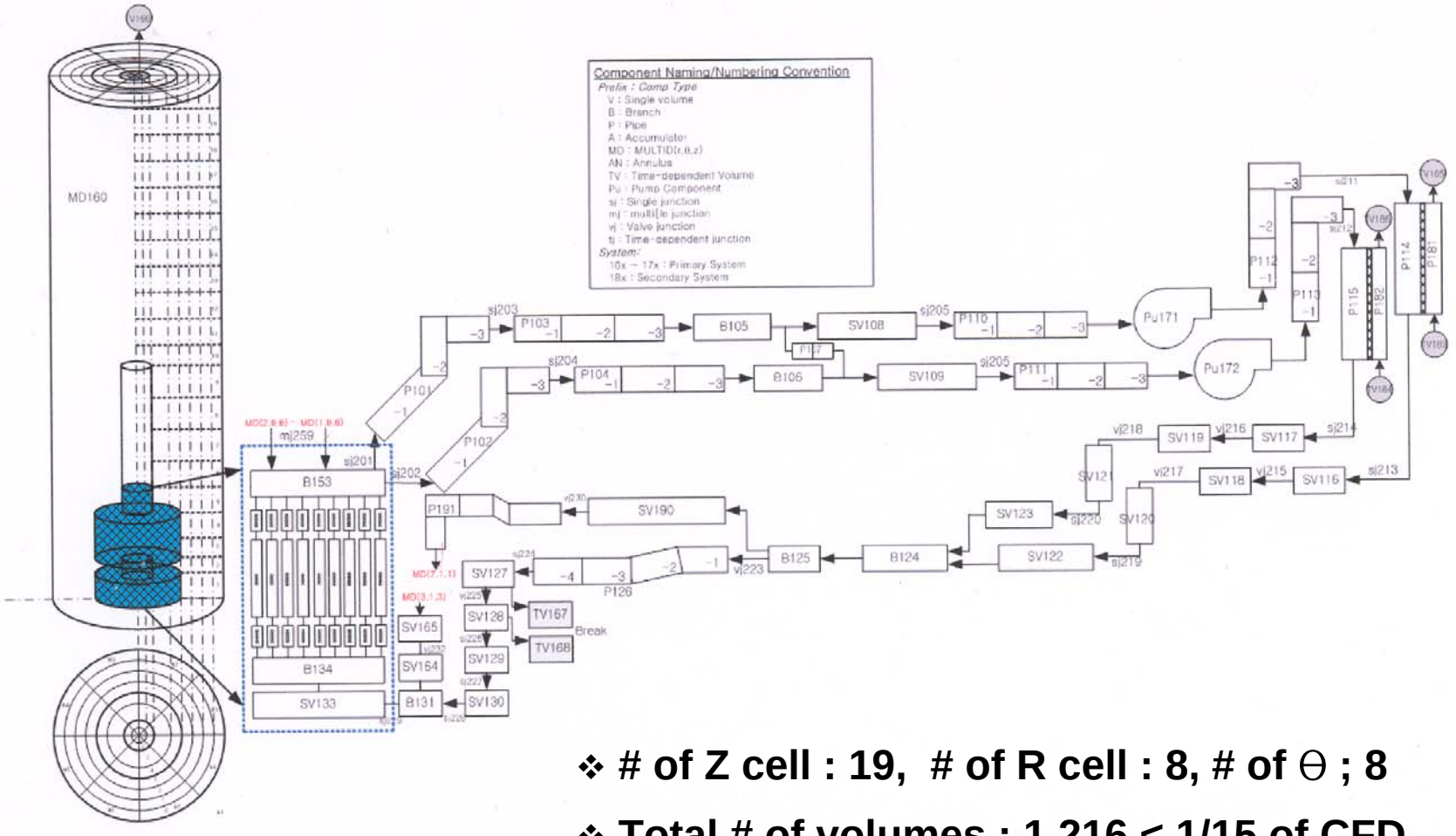
MARS simulation of the HANARO Pool (1/3)

❑ Nodalization of the HANARO



- ❖ # of Z cell : 19, # of R cell : 8, # of Θ ; 8
- ❖ Total # of volumes : 1,216 < 1/15 of CFD

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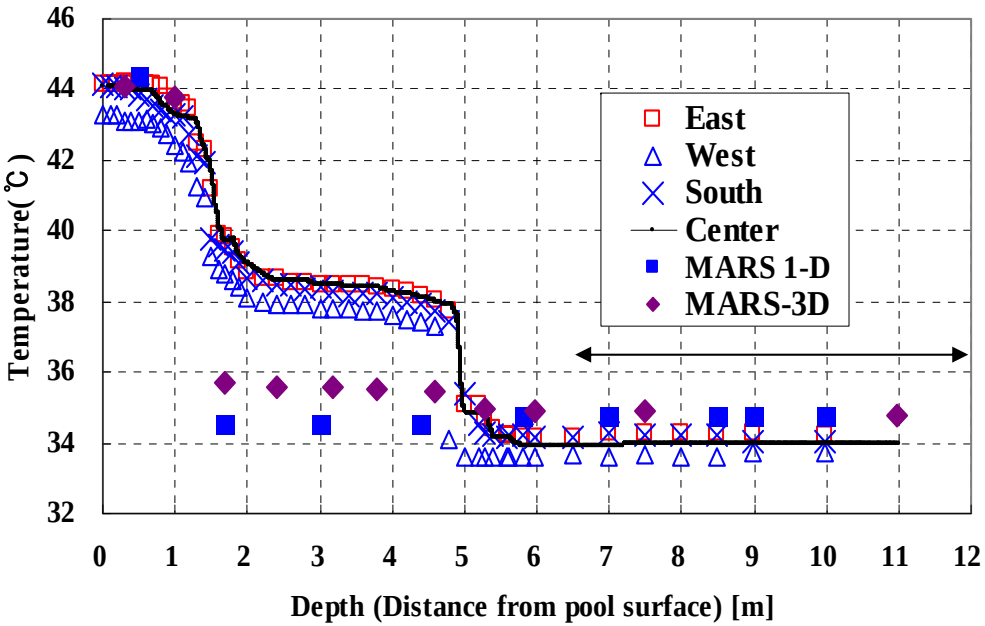
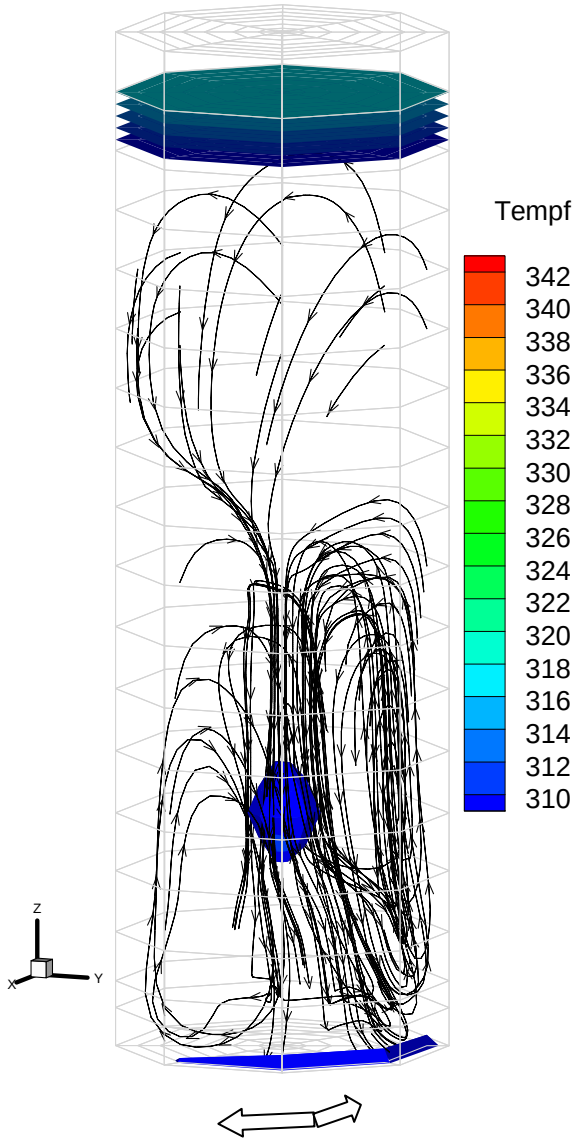
MARS simulation of the HANARO Pool (2/3)

Simulation results

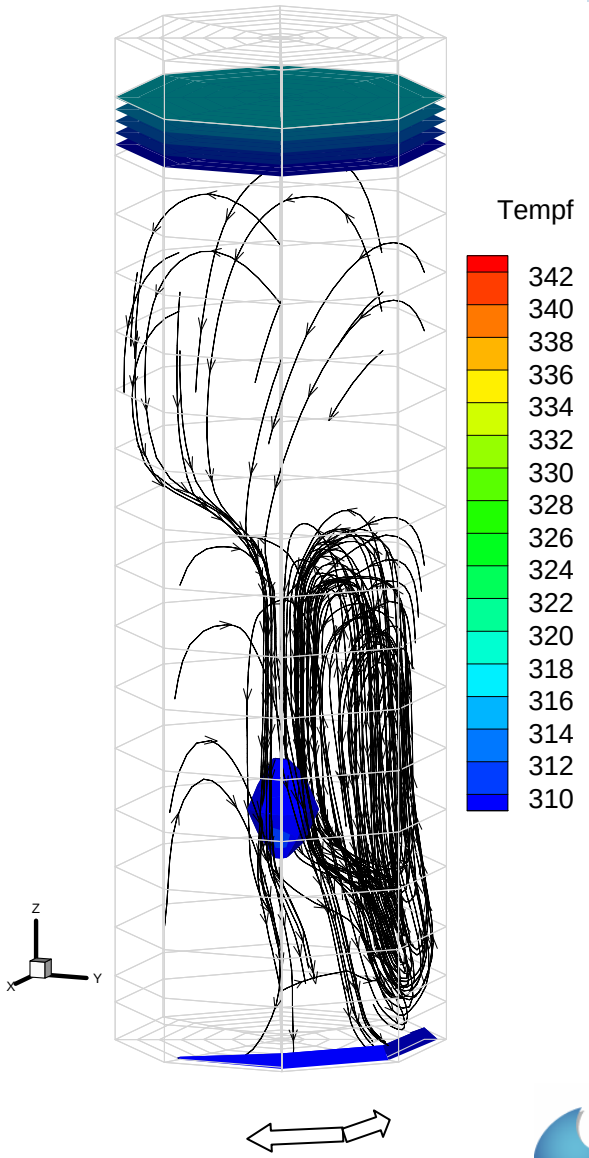
- Simulation
  - With a typical 1-D Nodalization for reactor pool
  - With 3-D Nodalization
- In overall, similar flow pattern with actual conditions
- Axially dominant flow, less circulating flow than that by CFD
  - Relatively smaller nodes
  - 1-D based solution method
- But, increased temperature in the middle region for calculation with 3-D nodalization



MARS simulation of the HANARO Pool (3/3)



1 : 1.5



1 : 2

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Concluding Remarks

- **Understandings of 3-D flow behaviours in the HANARO pool**
- **Simulation by the MARS code showed**
  - the possibility to give reasonable prediction for the 3-D flow behaviour in the HANARO reactor pool
  - the necessity to consider 3-D behaviour for 1-D calculation
- **This capability may be useful to predict the effect of 3-D flow phenomena in a RR on**
  - the core thermal margin during flow reversal transient
  - the establishment of natural circulation

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Thank you for your attention !!!

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