Preliminary Simulation Results for 6x12 Rod Bundle Test Using OpenFOAM

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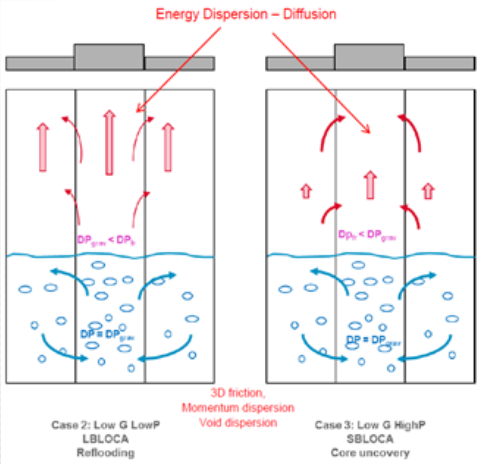
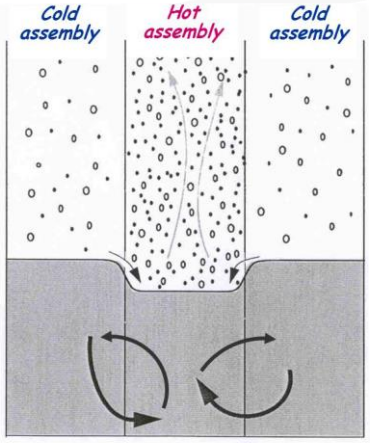
01 Background and Objective

- Under accident conditions, e.g. loss of coolant accident, fuels can be partially exposed and three dimensional cross-flow mixing can take place among assemblies with different burn-up, or decay heat levels.

- To explore single-phase turbulent-mixing phenomena across sub-channels, a 4 x 6 rod bundle test, PRIUS-I, was conducted and currently a 6 x 12 rod bundle test, PRIUS-II, is being conducted

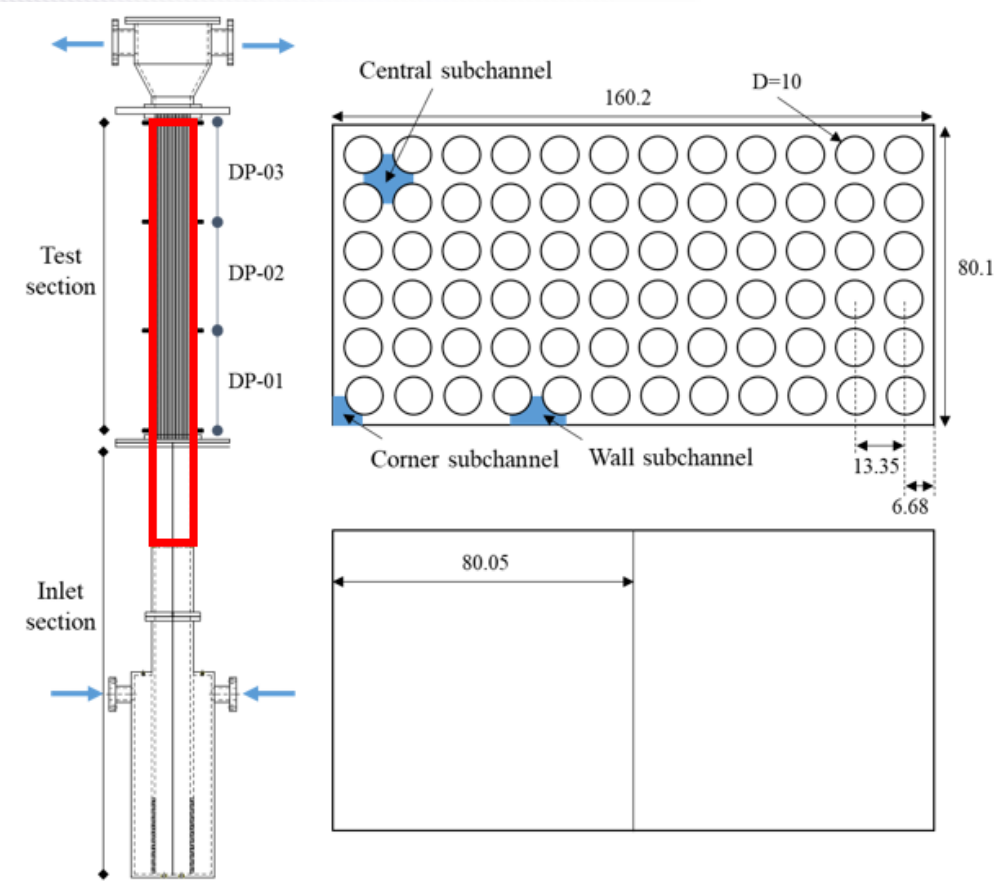
- In this research, we used OpenFOAM, a free CFD software, for preliminary simulation of PRIUS-II. Through the calculation, we will assess the adequacy of turbulence models.





Multi-D. two-phase flow phenomena at LOCA (D. Bestion, 2015)

02 Experimental facility- PRIUS-II



Unheated 6x12 rod bundle
(height of 1.5 m, atmospheric P.)

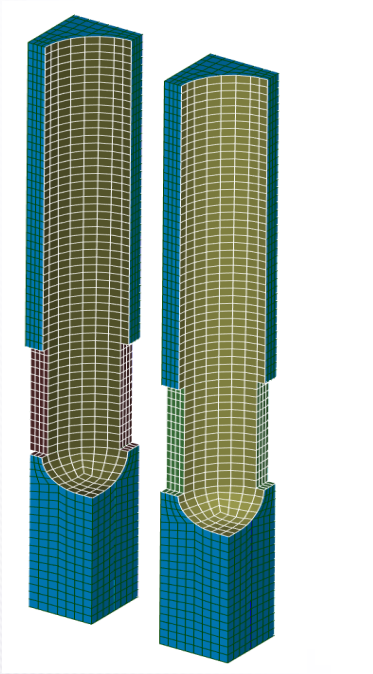
ReDh =0 −15,000 (capacity)

Velocity/ Turbulence Intensity Measurement:
PIV-matching index of refraction (MIR) technique

PRIUS-II Schematic (Red area: computational domain)

03 Calculation Set-up

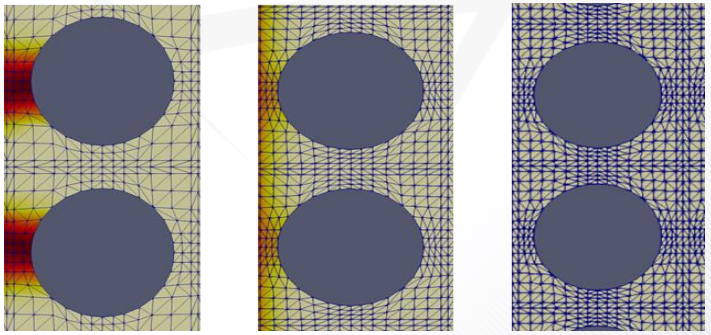
- Grids were generated using SALOME software.
- Hexahedral grids was used.
- Three types of grids were made for grid sensitivity tests.



3D hexahedral mesh models for quarter-blocks

Grid cell numbers

	Grid1	Grid2	Grid3
Cell number	7.1 millions	12.1 millions	23.4 millions



Grids near PRIUS-II rod bundles

03 Calculation Set-up

- OpenFOAM v2006(the latest version)
- Parallel computing with 30 cores
- simpleFoam solver for incompressible flow
- k-ω SST/ Shin quadratic k-ε turbulence model
- Steady calculation
- Fluid property reflected

Default turbulence models in OpenFOAM

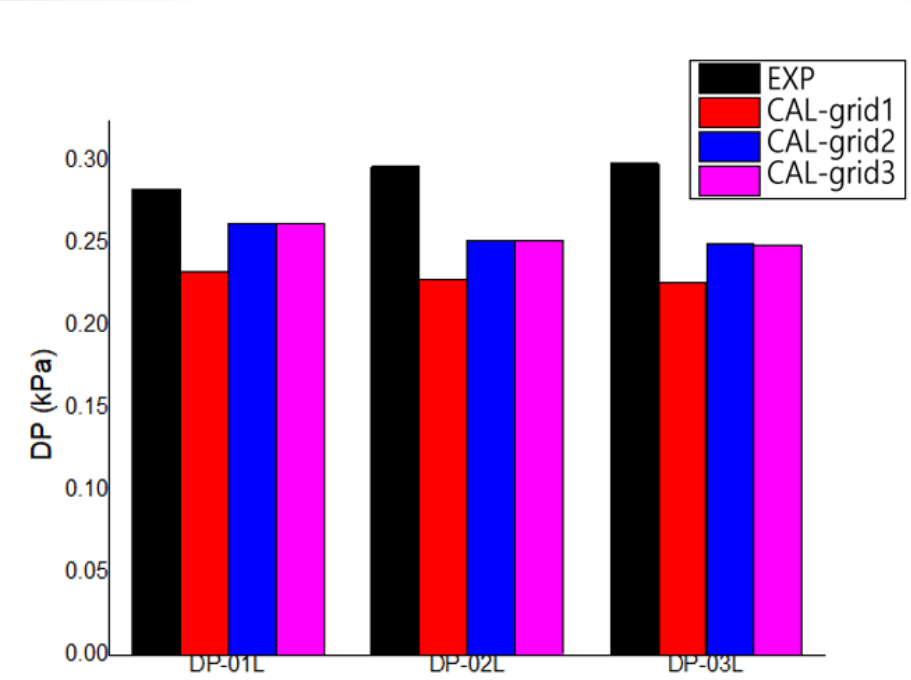
Model Type	Turbulence Model	Model Name
Linear-Eddy Model	k-epsilon k-omega-SST	kEpsilon kOmegaSST
Non-Linear-Eddy Model	Lien cubic k-epsilon Shin quadratic k-epsilon	LienCubicKE ShihQuadraticKE
Reynolds Stress Transport Model	Launder, Reece and Rodi Speziale, Sarkar and Gatski	LRR SSG

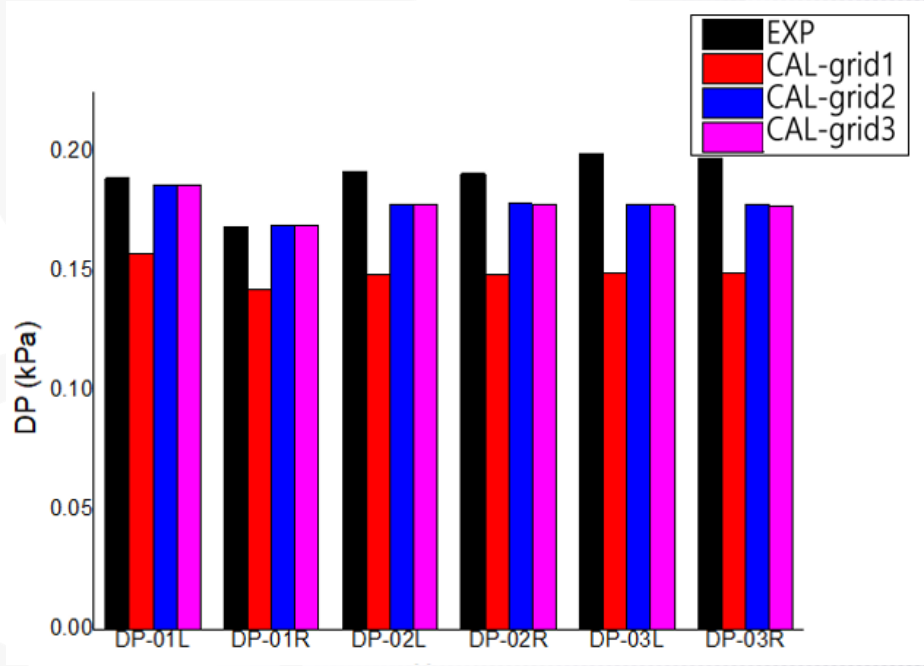
04 Calculation Results

- For a preliminary water experiment, dP values were calculated using different grids.
- Grid 2/3 gave the converged results.
- Grid 3 was used for the main calculations.

Preliminary experiment condition

	Case 1	Case 2
Mass flowrate (left/right)	2.164 kg/s/ 1.165 kg/s	2.164 kg/s/ 2.164 kg/s

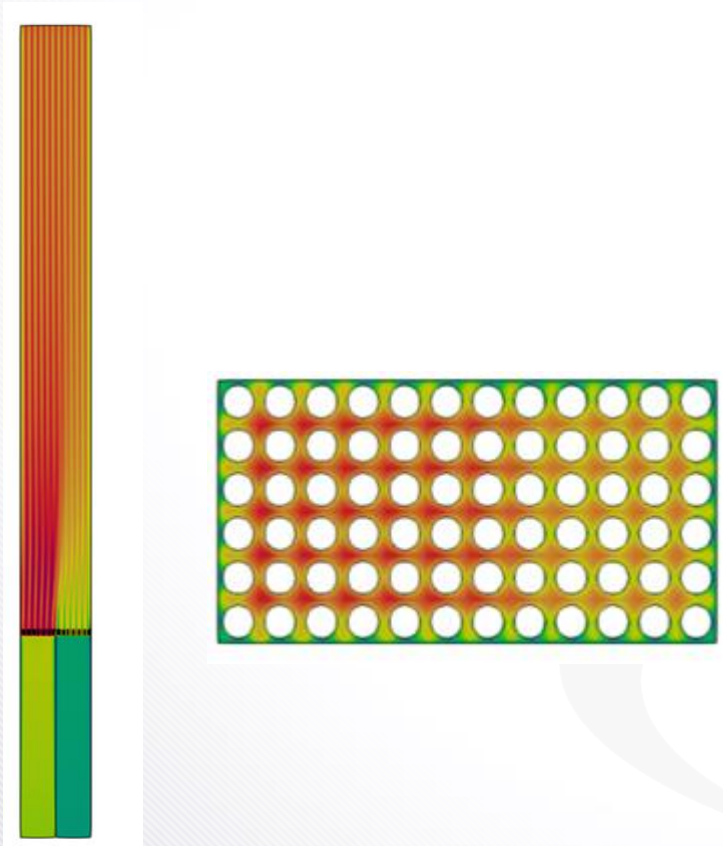




Grid sensitivity results for water test

04 Calculation Results

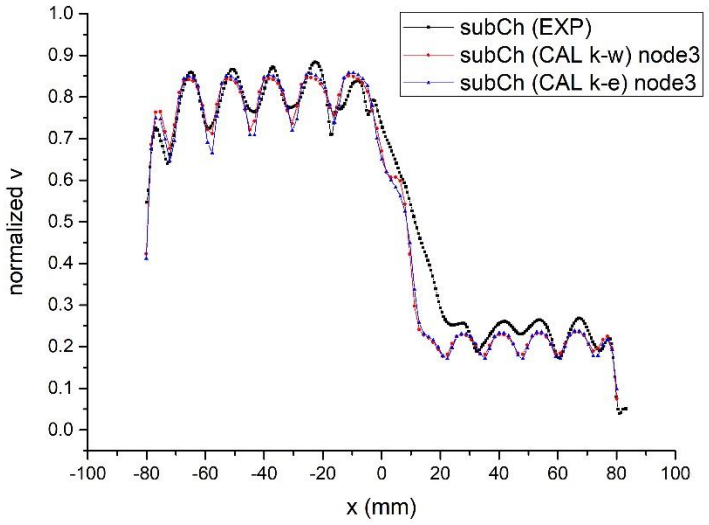
- For the main test using NaI-water solution, different turbulent models were assessed.
- OpenFOAM calculation simulated the gradual mixing of fluid.
- k-ω and k-ε turbulent models gave almost identical velocity profile, which was similar to the measured values.



Velocity profile (Left: side view, right: top view)

Main experiment condition

	Case 1
Mass flowrate (left/right)	8.860 kg/s/ 2.215 kg/s



Velocity profile

05 Conclusion

- PRIUS-II experiments are being conducted for examining cross-flow mixing models.
- In parallel to the experiment, a CFD code calculation using openFOAM was prepared to evaluate turbulence models and to provide unmeasured local values
- A preliminary calculation was made using an incompressible solver for steady flow
- The adequacy of the generated grid was confirmed through a grid sensitivity study against water experiment results.
- For the main test using NaI-water solution, different turbulent models were assessed.

THANK YOU