Comparison between CUPID and CTF for Subchannel Scale Thermal-Hydraulic Analysis of Single Fuel Assembly Problem

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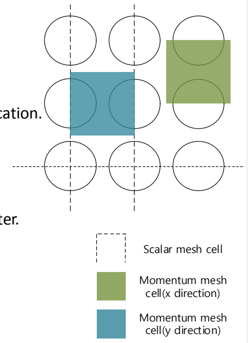
Introduction

❖ **Subchannel scale thermal hydraulic codes**

- CTF
  - Improved version of COBRA-TF by Pennsylvania State Univ.
  - Grid system : **staggered grid**
  - Vector variables and scalar variables are stored in different location.
- CUPID
  - In-house code developed by KAERI.
  - Grid system : **collocated grid**
  - Vector variables and scalar variables are stored in the cell center.



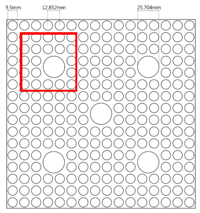
❖ **Objective of this study**

- Code-to-code comparison between CUPID and CTF
  - PSBT thermal mixing test
  - APR1400 single assembly problem

APR1400 Single Assembly Modelling

❖ **Geometry**

- 236 fuel rods, 5 guide tubes, with 9 spacer grids

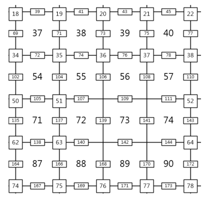


❖ **Power input from n-TRACER**

- Non-uniform power distribution

❖ **Guide tube modelling**

- CUPID
  - Small flow area at the center of the guide tubes
- CTF
  - No flow through the guide tube
  - Wall model around the center of the guide tubes



Grid information of CUPID

❖ **Wall friction factor correlation**

- McAdam's correlation

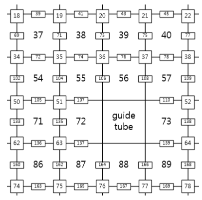
$$f_w = 0.204Re^{-0.2}$$

❖ **Mixing vane model**

- Grid-directed cross flow model

$$\overrightarrow{M_l^{GDCF}} = f_{lat,SG}^2 (u_l^2)(\rho_l) A_{gap} S$$

- $f_{lat,SG}$: lateral convection factor
- u_l : axial liquid velocity
- ρ_l : liquid density
- A_{gap} : cross-sectional area of the gap
- S : factor to account for the direction of the force(-1, 0 or 1)

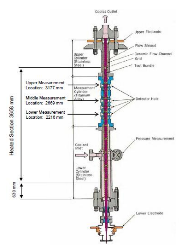


Grid information of CTF

PSBT Thermal Mixing Test

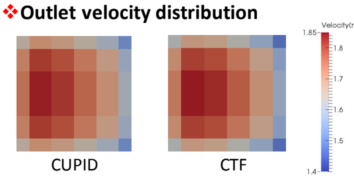
❖ **Geometry of PSBT test facility**

- Active length : 3.658m
- 25 fuel rods with 15 spacer grids
- Number of axial mesh : 50



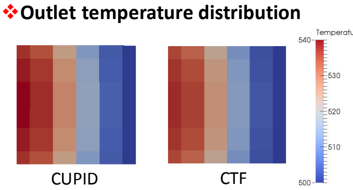
PSBT test facility*

❖ **Outlet velocity distribution**

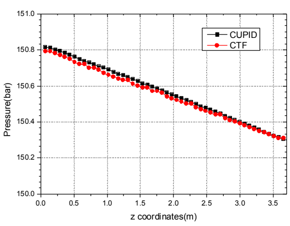


CUPID CTF

❖ **Outlet temperature distribution**



CUPID CTF



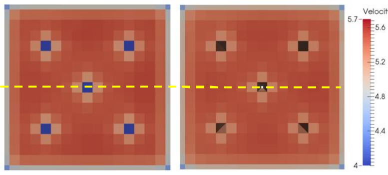
Pressure drop comparison

*A. Rubin, A. Schoedel, M. Avramova, *OECD/NRC BENCHMARK BASED ON NUPEC PWR SUBCHANNEL AND BUNDLE TESTS (PSBT) Vol 1*, 2010

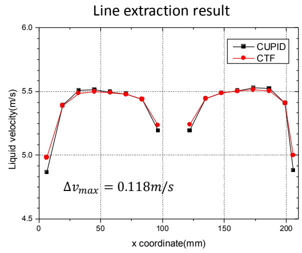
APR1400 Single Assembly Problem

❖ **Result without mixing vane model**

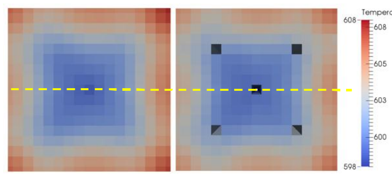
- Outlet velocity distribution



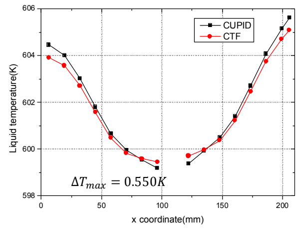
CUPID CTF



- Outlet temperature distribution

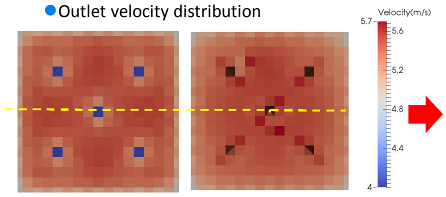


CUPID CTF

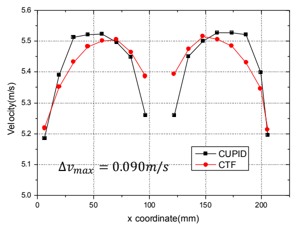


❖ **Result after applying mixing vane model**

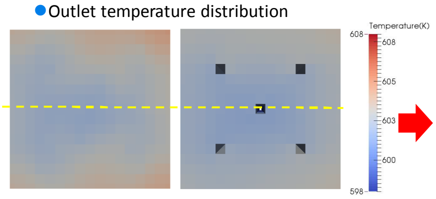
- Outlet velocity distribution



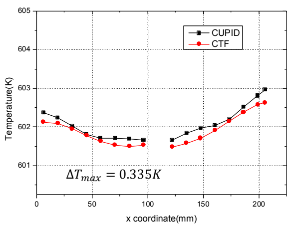
CUPID CTF



- Outlet temperature distribution

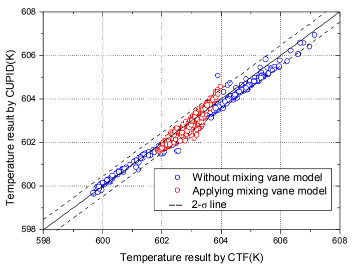


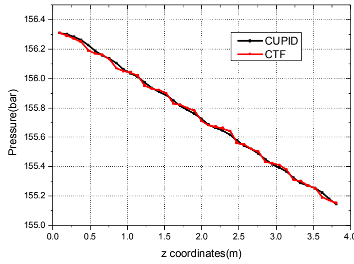
CUPID CTF



❖ **Quantitative comparison between CUPID and CTF**

- Temperature comparison at the outlet
- Pressure drop comparison





Conclusion & Future Work

❖ **Code-to-code verification using CTF**

- APR1400 single assembly problem and PSBT thermal mixing test
- Spacer grid effects are well predicted by CUPID.

❖ **Code-to-code verification with two-phase problems**

❖ **Improvement of computing time using MPI processing**