Validation of the CORONA Code with SNU Multi-block Experiments

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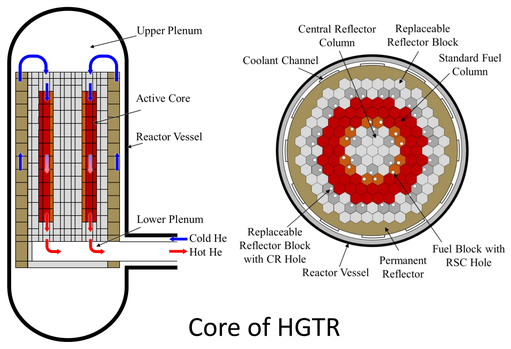
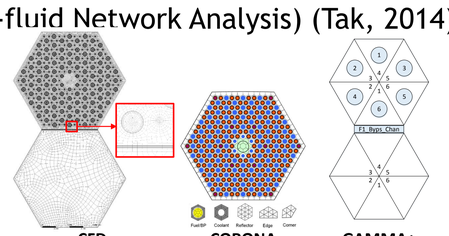
Introduction

- High Temperature Gas-cooled Reactor
  - One of Gen-IV reactors
  - Production of hydrogen as well as electric power
  - Uncertainty of the flow and temperature distribution because of bypass gap and cross gap



Core of HGTR

- CORONA (Core Reliable Optimization and thermo-fluid Network Analysis) (Tak, 2014)
  - 3-D solid conduction and 1-D fluid analysis
  - Low computational cost
  - High resolution of solid temperature distribution



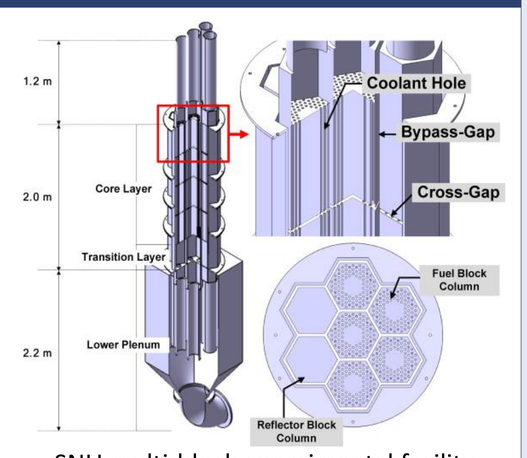
- A validation work of the CORONA code, SNU (Seoul National University) multi-block experiment was simulated and the prediction results were compared with the experimental data and the results of other codes. In addition, cross flow model sensitivity test was carried out to find out proper model for flow analysis of the block type core of HTGR.

Description of SNU Multi-block Experiment

- 7 columns, 4 layers (5 fuel columns 2 reflector columns)
- Working fluid: air at room temperature and pressure
- 1/2 scaling ratio

Test cases

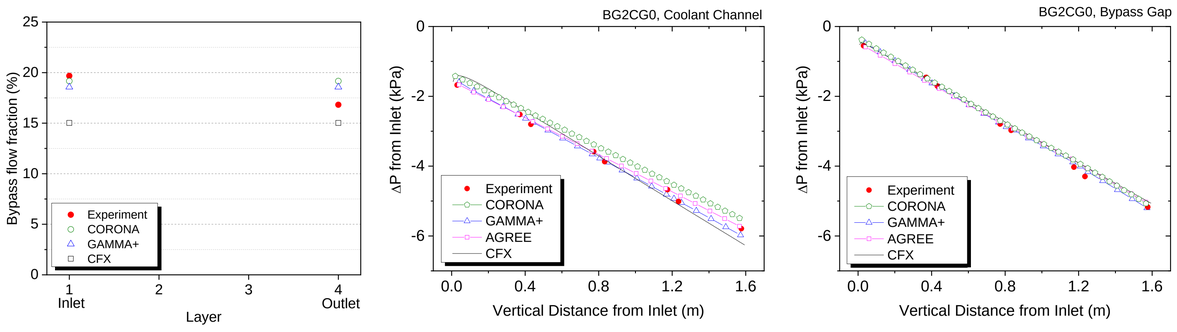
Test case	Bypass gap from top to bottom (mm)	Cross gap from top to bottom (mm)
BG2CG0	2-2-2-2-2	0-0-0-0
BG6242CG2	6-2-4-2-2	2-2-2-2
BG62420CG2	6-2-4-2-0	2-2-2-0



SNU multi-block experimental facility

Results

BG2CG0



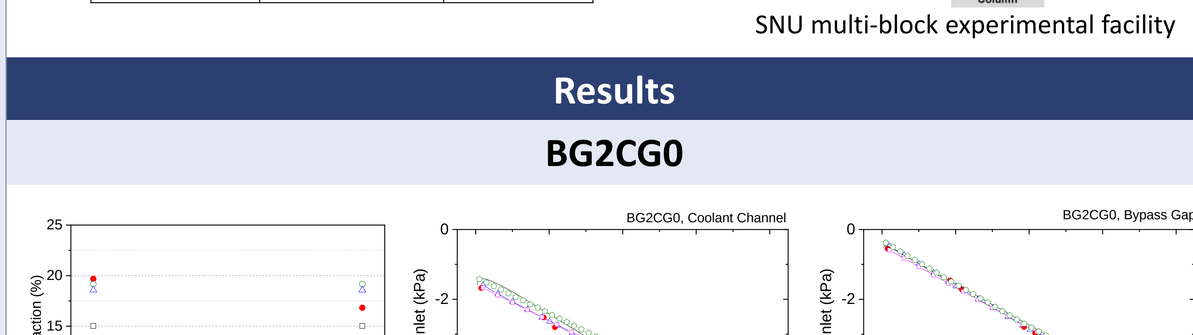
Comparison of calculation results

- Prediction results of CORONA show good agreement with experimental data and the calculation results of GAMMA+, AGREE, and CFX.
- Since the bypass gap was set to be 2 mm in the CFX simulation, there is some discrepancy in bypass flow fraction between CFX results and others.

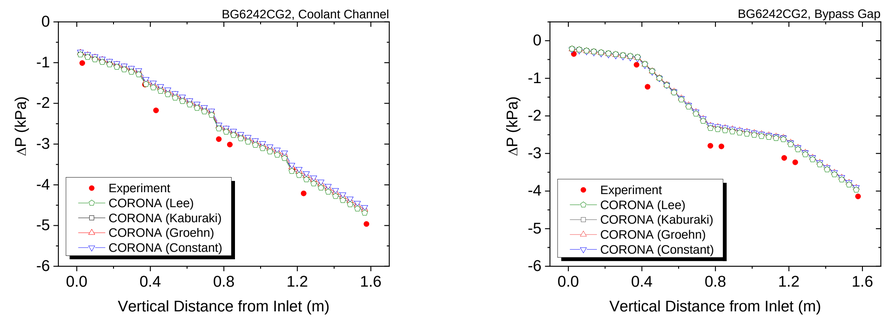
Geometrical information of bypass gap for each layer: BG2CG0

Layer	Bypass gap	Hydraulic diameter	Flow area
	(mm)	(mm)	(mm^2)
4	2.35	4.73	246
3	2.37	4.77	248
2	2.45	4.93	256
1	2.36	4.75	247

BG6242CG2



Comparison of calculation results



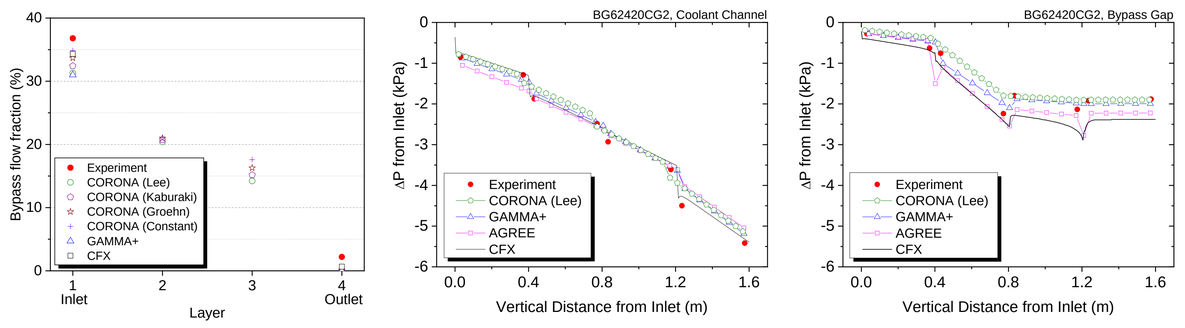
Cross flow model sensitivity test results

- Calculation results of CORONA, GAMMA+, AGREE, CFX are all in good agreement with experimental data.
- Used models in the cross flow model sensitivity test were Lee, Kaburaki, Groehn, and constant loss coefficient (K=1.5) and they are all in good agreement with experimental data.

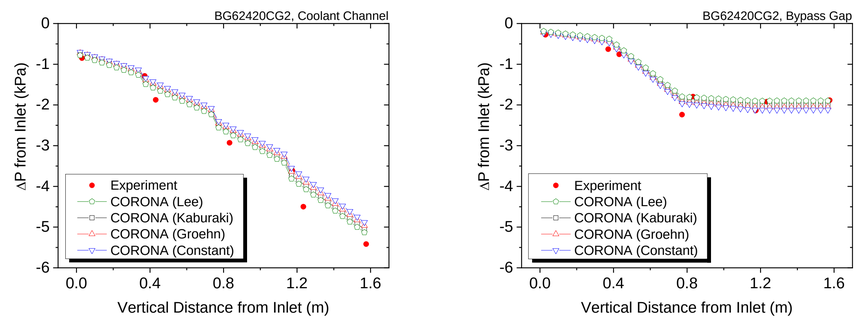
Geometrical information of bypass gap for each layer: BG6242CG2

Layer	Bypass gap	Hydraulic diameter	Flow area
	(mm)	(mm)	(mm^2)
4	6.07	12.3	641
3	2.56	5.15	268
2	4.89	9.91	515
1	2.43	4.89	254

BG62420CG2



Comparison of calculation results (Experiment, CORONA, GAMMA+, AGREE, CFX)



Cross flow model sensitivity test results

- The bypass gap at the transition layer was set to 0 mm which leads to whole bypass flow at the third layer from the top goes through the cross gap so that the effect of cross flow can be emphasized.
- The prediction results of CORONA show good agreement with experimental results and calculation results of GAMMA+, AGREE, and CFX.
- The flow stagnation at the bottom bypass gap was well captured in the code.
- No significant difference was observed in pressure drops between the models even the cross flow was emphasized.
- Even GAMMA+ slightly under predicts bypass flow fraction (4.8%p), considering the uncertainty of the experiment, the results are quite reasonable.

Geometrical information of bypass gap for each layer: BG62420CG2

Layer	Bypass gap	Hydraulic diameter	Flow area
	(mm)	(mm)	(mm^2)
4	6.15	12.5	650
3	2.64	5.31	276
2	4.71	9.55	596
1	2.65	5.34	278

Conclusions

- CORONA was validated with SNU experimental data and compared with other flow analysis codes.
- Overall pressure drop results were all in good agreement.
- As a results of the sensitivity test of the cross flow models, it was confirmed that all models were applied properly and no significant difference in results was found between the models.
- Therefore, from this study, it is concluded that CORONA can predict the flow distribution of the core of the block type HTGR and expected that the code can contribute to design core of HTGR by reliably predicting the flow distribution.

Acknowledgements

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIP) (No. 2017M2A8A1014757).

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