Assessment of Prediction Capability on Two-Phase Flow Pressure Drop Using MARS-KS

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CONTENTS

Ⅰ. Introduction

■ Passive Safety System Using Natural circulation

▶ Passive Safety Systems(PSSs) using natural circulation flow are widely applied in the advanced nuclear reactor.

- The performance prediction of the PSSs has been mainly conducted with system codes.
- For the reliable prediction of the PSS heat removal performance, the system analysis code should have the capability to predict
  1) the heat transfer coefficient on the heat exchanger
  2) the pressure drop in the natural circulation loop

▶ In this study, the prediction capability on the pressure drop and the natural circulation flow rate in the PSS is systematically evaluated by using MARS-KS 1.5.

II. Description of Bettis Experiment Facility

■ Bettis Natural Circulation Loop (Mendler et al., 1961)

▶Geometry

- Test section: 0.20”~0.27” x 1.0” x 27” (Dh: ~ 1cm)
- Test Loop: 174.5” x 179” (1.5” Sch.80 Pipe)

▶Test conditions

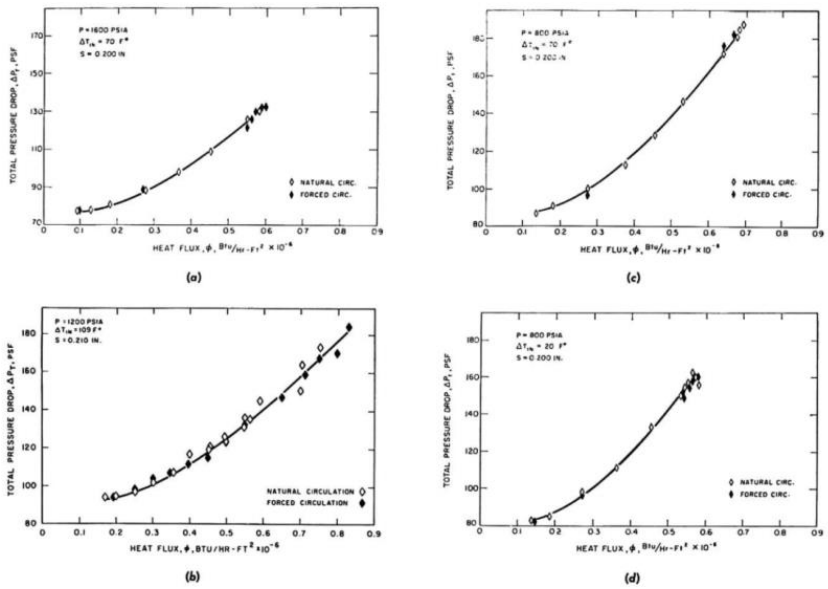
- System pressure: 55.16 ~ 137.9 kPa
- Mass flux: 200 ~ 700 kg/m^2s
- Exit quality: 0.0~0.7 (Thermodynamic)
- Inlet sub-cooling: 10~60℃

▶Experiment provides data on flow rate/pressure drop according to heat flux

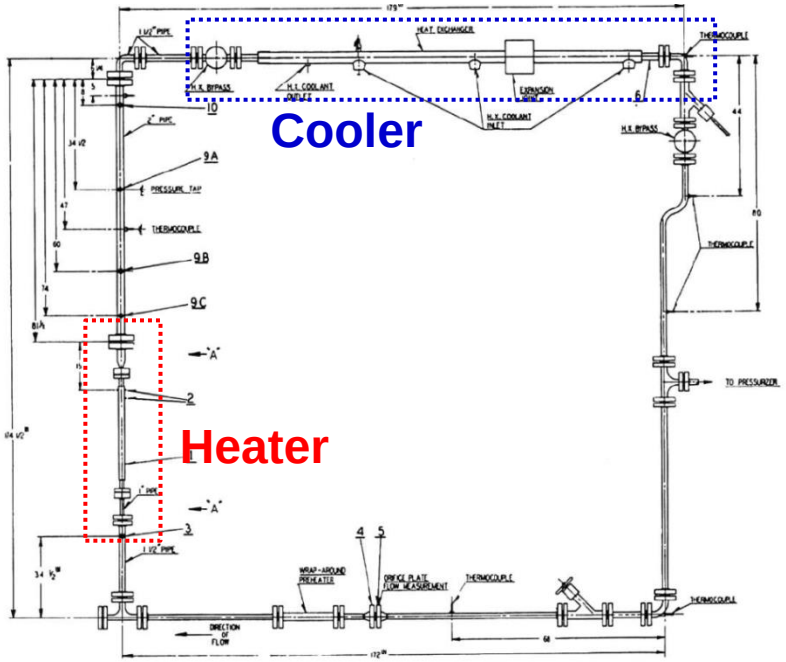
- Single/Two phase flow
- Forced/Natural circulation flow

II. Description of Bettis Experiment Facility

■ Bettis Natural Circulation Loop (Mendler et al., 1961)



Experiment results

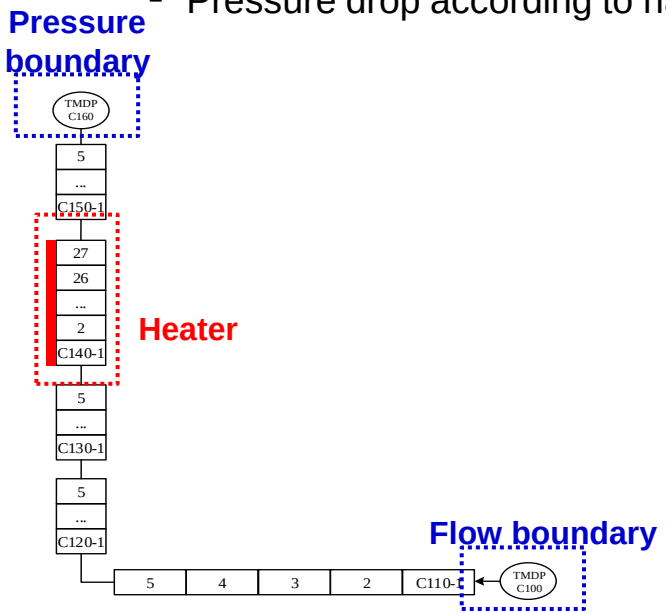


Bettis`s Natural Circulation Loop

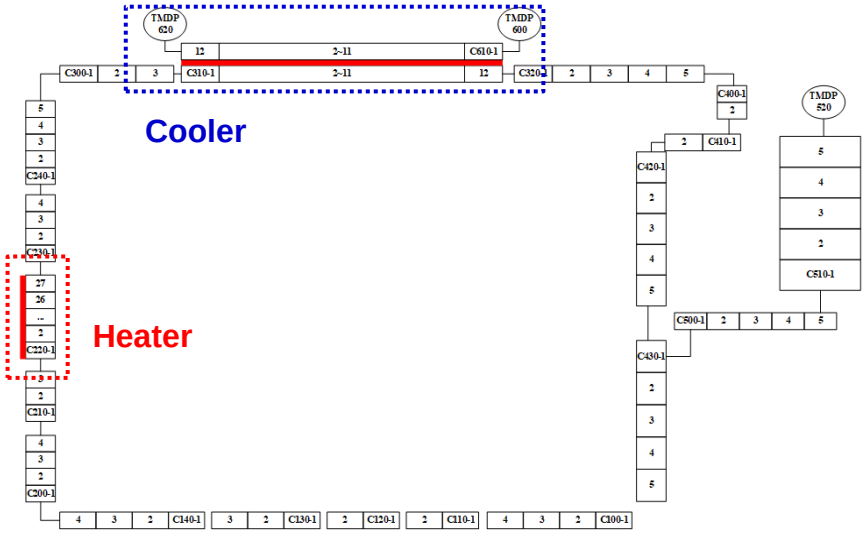
■ MARS Nodalization

▶In this study, two modeling method are used for analysis of experiment

- Case 1: Modeling using flow and pressure boundary conditions at the inlet and outlet of the heater
  - Pressure drop according to the exit quality at constant flow rate
- Case 2: Modeling the entire loop of an experiment
  - Pressure drop according to natural circulation flow rate



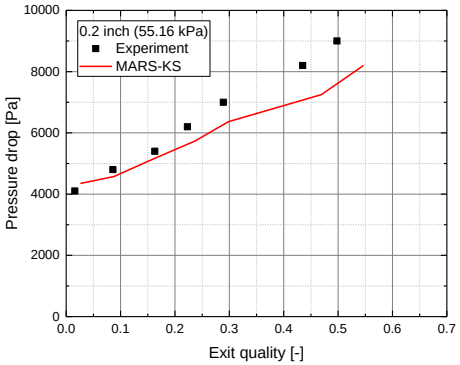
MARS Nodalization (Case 1)

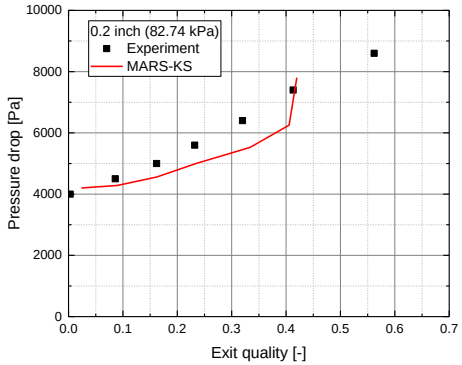


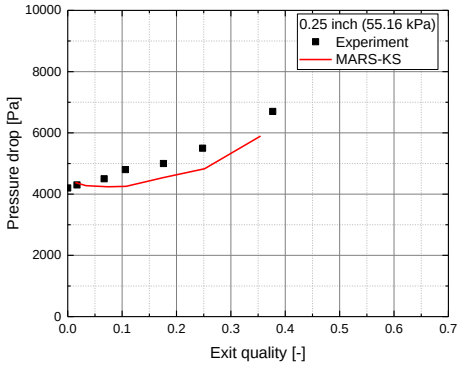
MARS Nodalization (Case 2)

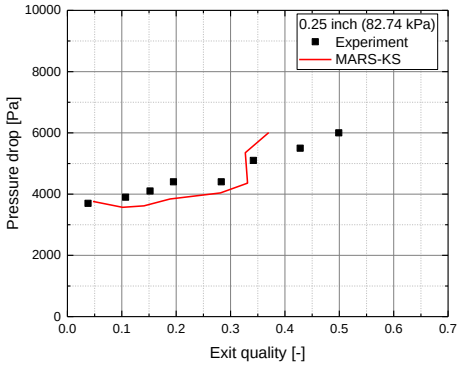
■ Case 1(Constant mass flow rate calculation)

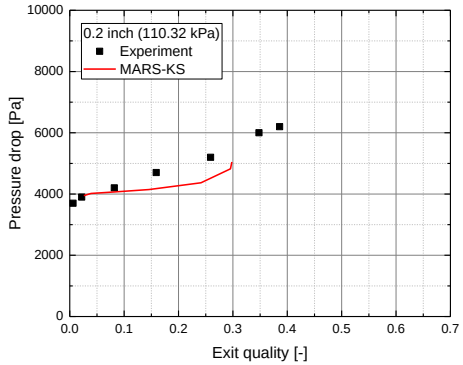
▶48 test on rectangular channel with equivalent diameters of 0.2 inch(8.5 mm), 0.25inch (10.7 mm) are simulated using MARS-KS 1.5.

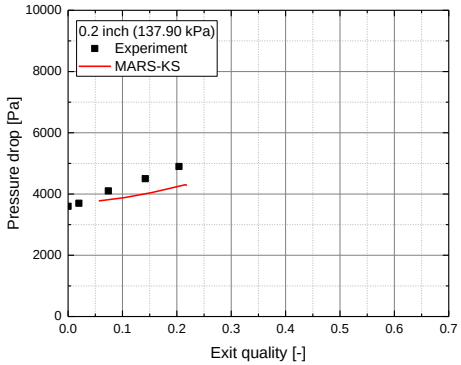


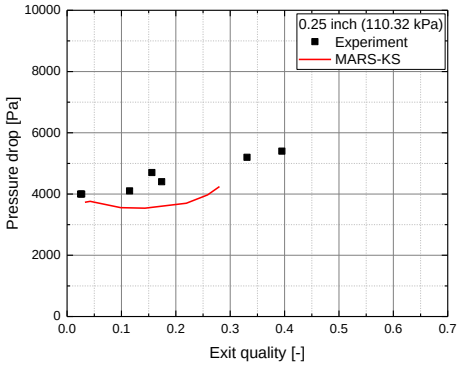












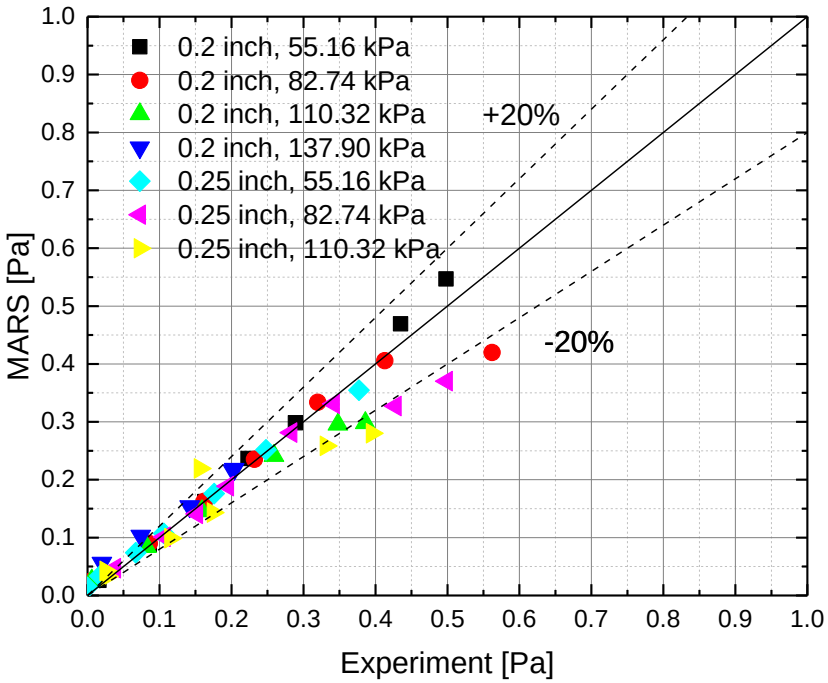
MARS calculation results (8.5 mm cases)

MARS calculation results (10.7 mm cases)

■ Case 1(Constant mass flow rate calculation)

▶Most of the results are predicted within 20 % error range

- Low heat flux case:
  - Quality/Pressure drop is higher than experiment
- High heat flux case:
  - Quality/Pressure drop is lower than experiment

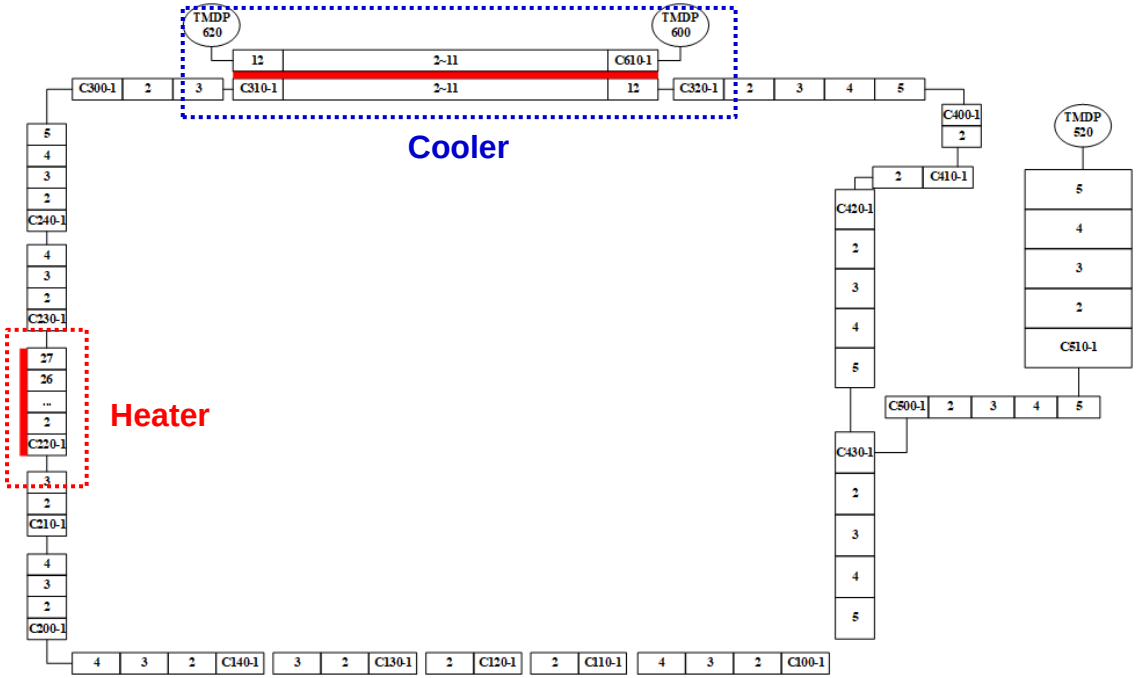


MARS calculation results

■ Case 2(Natural circulation flow calculation)

▶Modeling for the Bettis`s natural circulation loop

- System pressure was controlled by pressurizer (C510)
- Inlet sub-cooling was controlled by secondary coolant (C610)



MARS Nodalization for NC loop

■ Case 2(Natural circulation flow calculation)

▶MARS calculation result

- 0.2 inch, 55.16kPa case
  - Inlet temperature: 507.0 K
  - Heat flux: 429.02 kW/m^2
- Mass flow rate and pressure drop are over-estimated
  - Sensitivity tests about the K-factor and heat loss will be conducted

	Experiment	MARS with Boundary Condition	MARS with Natural Circulation Loop
Mass flow rate (kg/s)	0.06422	0.06422	0.07045
Exit quality (-)	0.016	0.026	0.018
Pressure drop (Pa)	4100	4348.4	4488.1

Ⅳ. Conclusion

■ Conclusion

▶ Assessment of Prediction Capability on Two-Phase Flow Pressure Drop

- Mendler et al. experiments were analyzed using the MARS-KS 1.5.
  - The calculation results were compared with experimental data
  - Most of the analysis results were predicted within 20% error
- Loop calculation for the Bettis experiment were conducted
  - Mass flow rate and pressure drop are over-estimated.
    - The appropriate K-factors and heat loss will be derived through various sensitivity analyses in the future.
  - Other experiments will also be analyzed using MARS-KS for the assessment.
  - The PSS prediction capability of MARS-KS 1.5 will be evaluated through the analysis of more diverse experimental devices

THANK YOU

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