2022 Korea Nuclear Society Spring Meeting

DHRS Performance Test Results of STELLA-2 & Comparison with MARS-LMR Analysis

(LOF Transient with 1 PDHRS and 1 ADHRS)

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May 20, 2022

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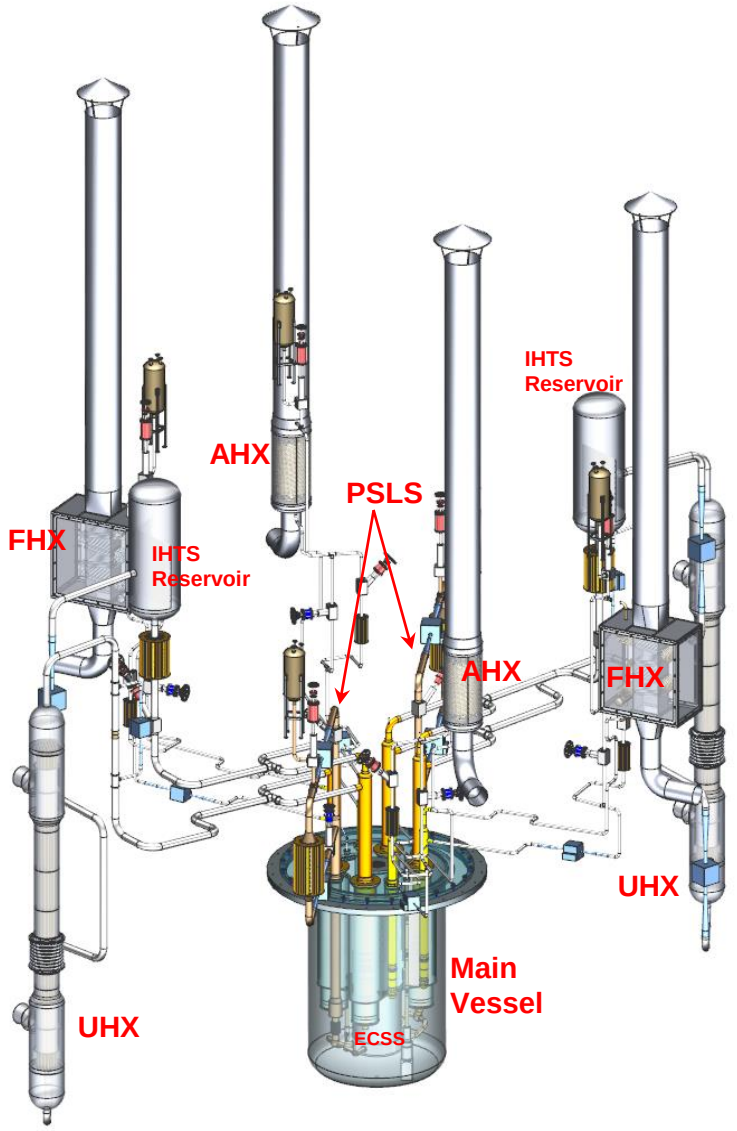
Introduction

STELLA Program

- Purpose :
  - To demonstrate safety performance of DHRS coupled with primary system
- Significance :
  - State-of-art large-scale sodium facility
  - Focus on transient behavior

Program Progress

- Phase I (separate effect test) completed in 2017
- Phase II (integral effect test) on-going
  - Construction finished in 2020



Introduction

STELLA-2 Capability

Major transients of concern

- **Loss of Heat Sink (LOHS)**

  i.e. Loss of F/W and SG failure

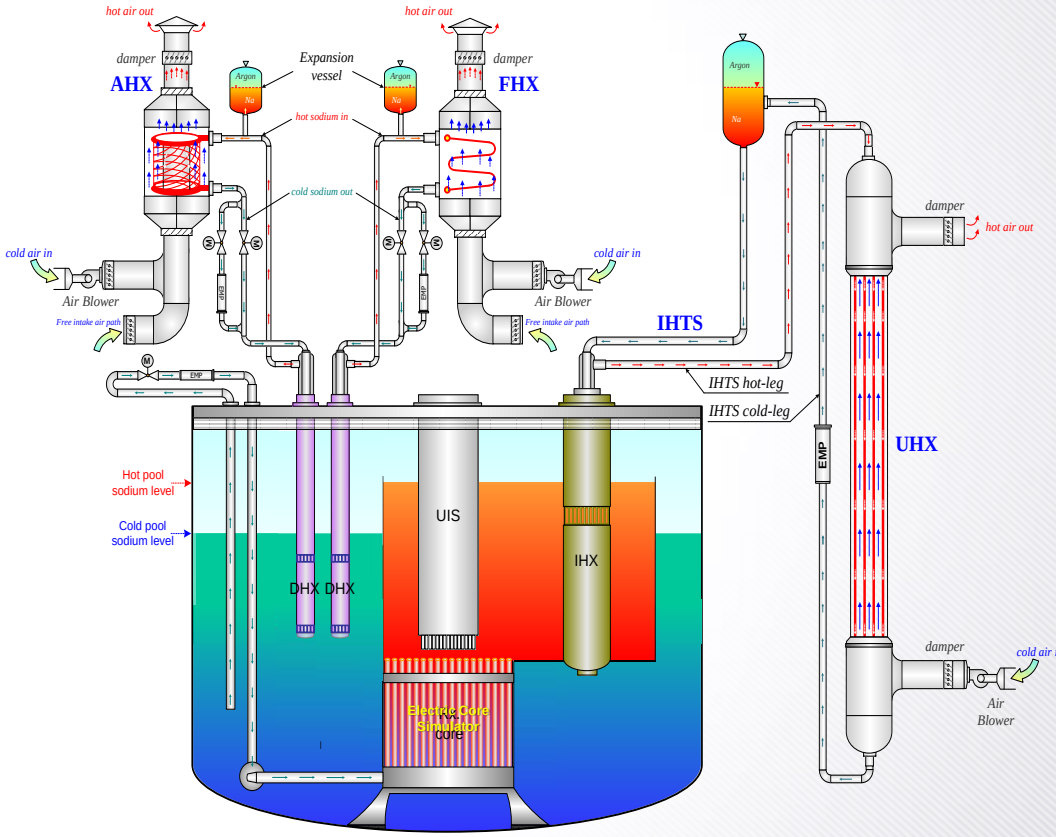
- **Loss of Flow (LOF)**

  i.e. PHTS pump failure (single or double)

- **PHTS pump discharge pipe break**

- **Total loss of DHR**

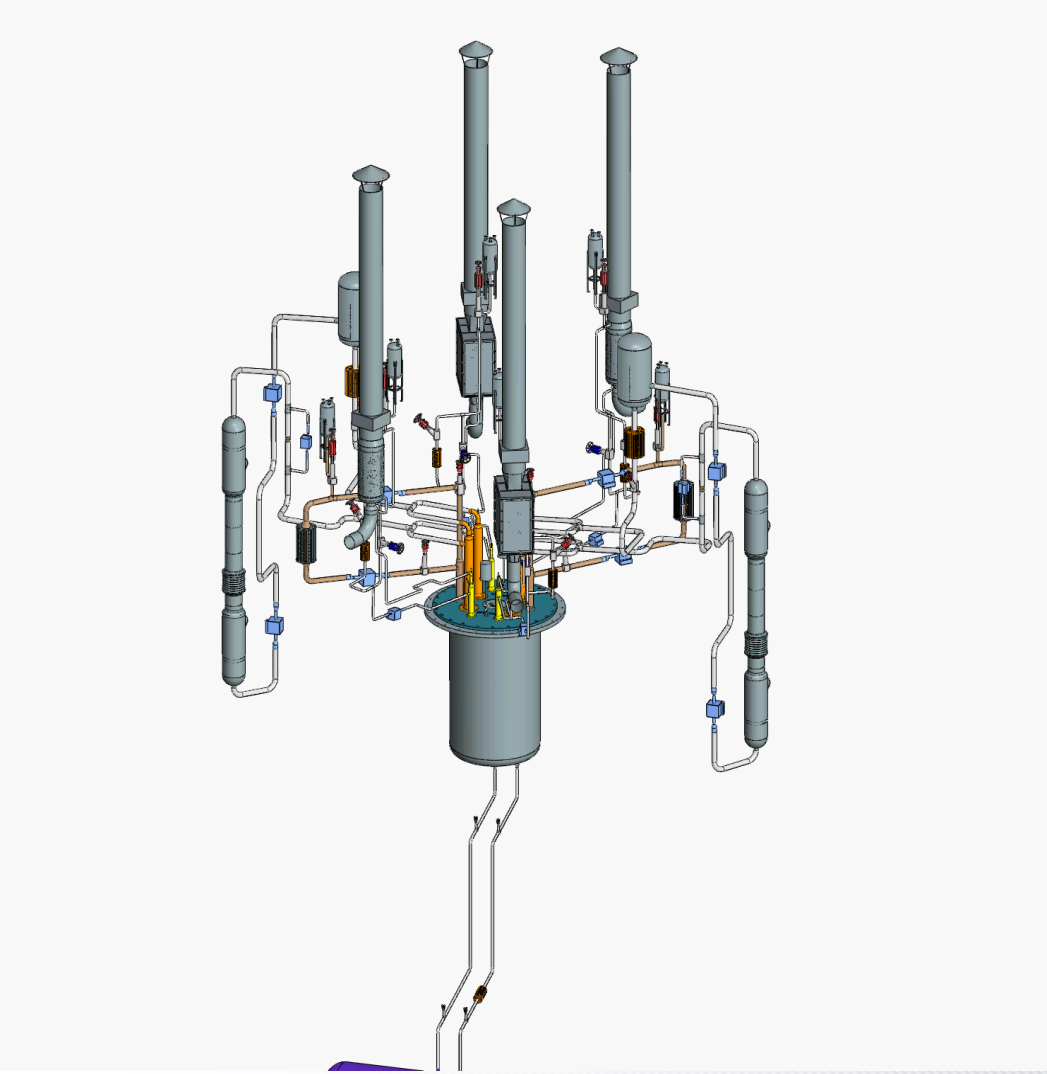
  (simulation of in-vessel retention with ex-vessel cooling)



STELLA-2 Design Features

System Layout

- Dynamic & Independent Loops
  - 1 vessel & 8 loops
  - 5 different types of heat exchanger
- Design Temp & Press
  - 600℃ & 5 bars
- Scale
  - 1/5 (length), 1/125 (volume)
- Dimension
  - 18 X 15 X 30 (m)
- Net Sodium Inventory
  - 15 tons
- Power
  - Total : ~3.0 MW



STELLA-2 Design Features

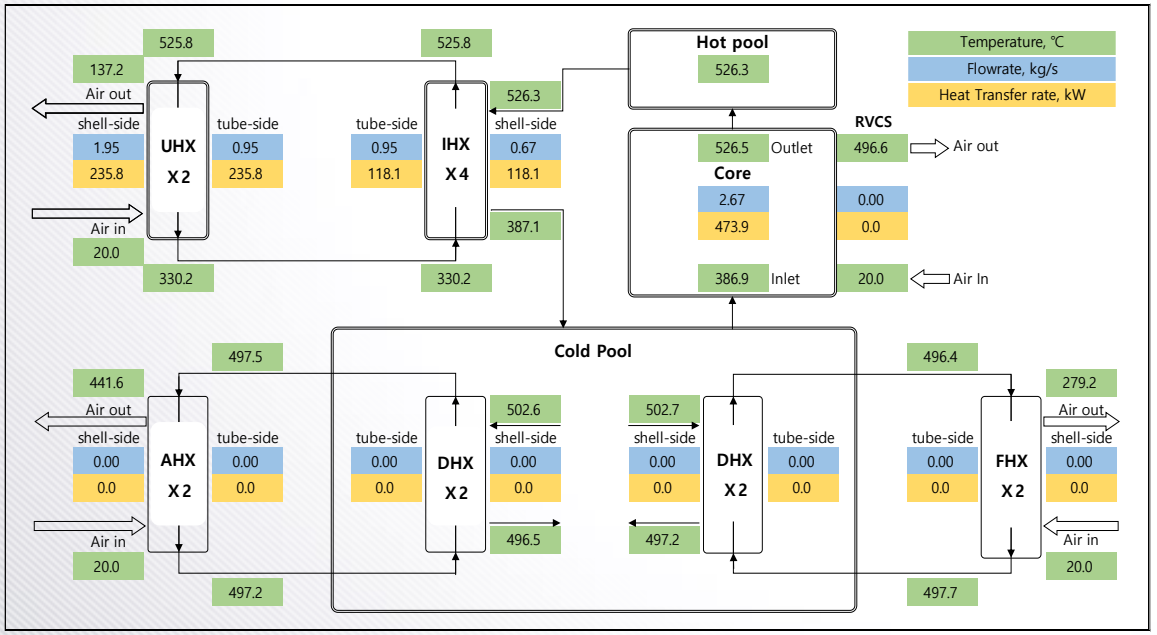
Test Condition

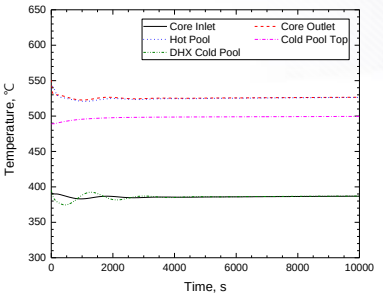
Target Transient

- LOF with 1 ADHRS and 1 PDHRS working

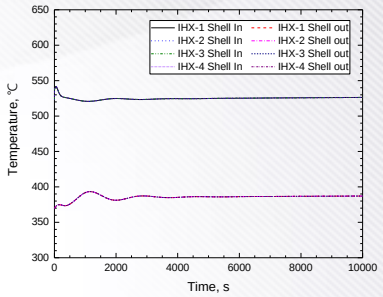
Steady-state Point

- Heat balance of normal operation

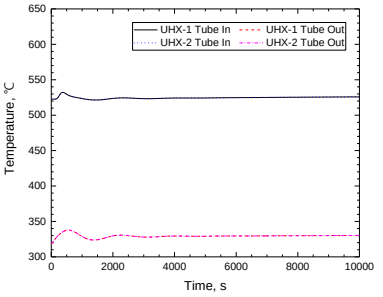




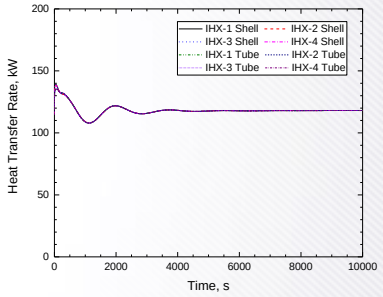
Core Temp



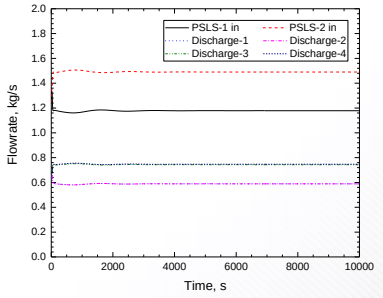
IHX Temp



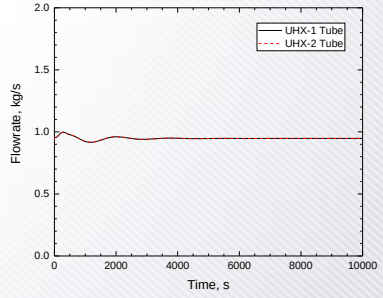
UHX Temp



IHX heat transfer



Primary Flow



Intermediate Flow

Test Condition

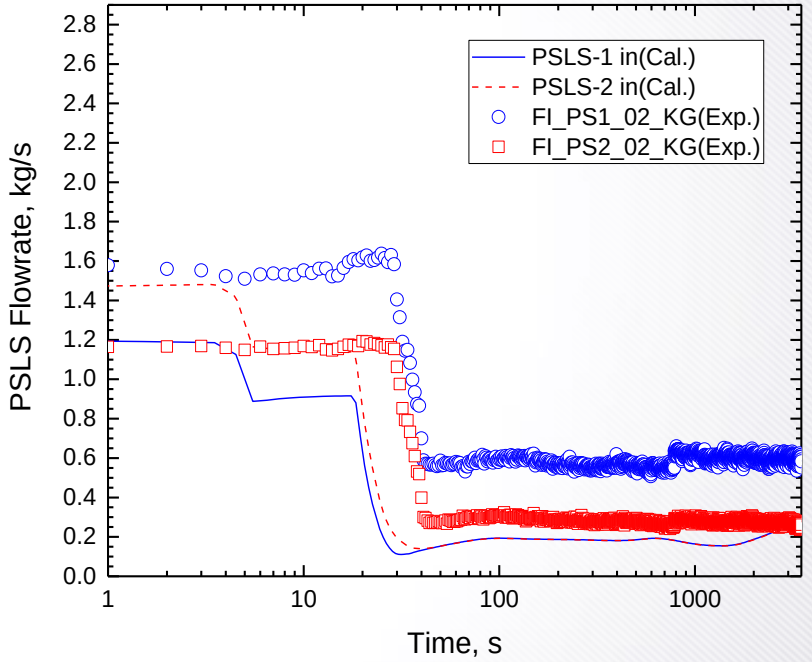
Event Sequence

- PHTS pump 1 & 2 stop
  - 1.25 kg/s → 0.0 kg/s
- IHTS pump 1 & 2 stop
  - 0.92 kg/s → 0.0 kg/s
- UHX 1 & 2 stop
  - Blower off
- Reactor trip
  - Starts to follow decay heat curve
- DHRS starts to operate
  - 100% 1 ADHRS (FHX) + 100% 1 PDHRS (AHX) working

Comparison btw Experiment & Code

Primary Flowrate

- Natural circulation flowrate comparison
- Difference 1
  - Code results are smaller by 35 ~ 53%
    - → Measurement uncertainties
    - → Unexpected heat loss
- Difference 2
  - PSLS-1 & PSLS-2 values are switched
    - → Asymmetrical flow distribution



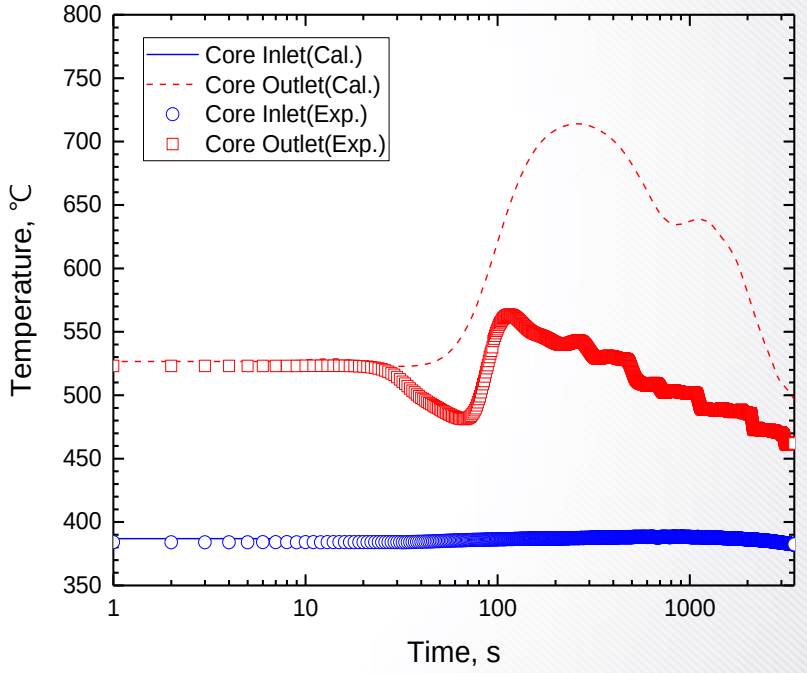
Primary Flowrate Comparison

Comparison btw Experiment & Code

Core In/Out Temperature Trend

- Long-term cooling capability is verified
- Difference
  - Code results of core ΔT is 1.6 ~2.8 larger

    → Unexpected heat loss



Core Temperature Comparison

Comparison btw Experiment & Code

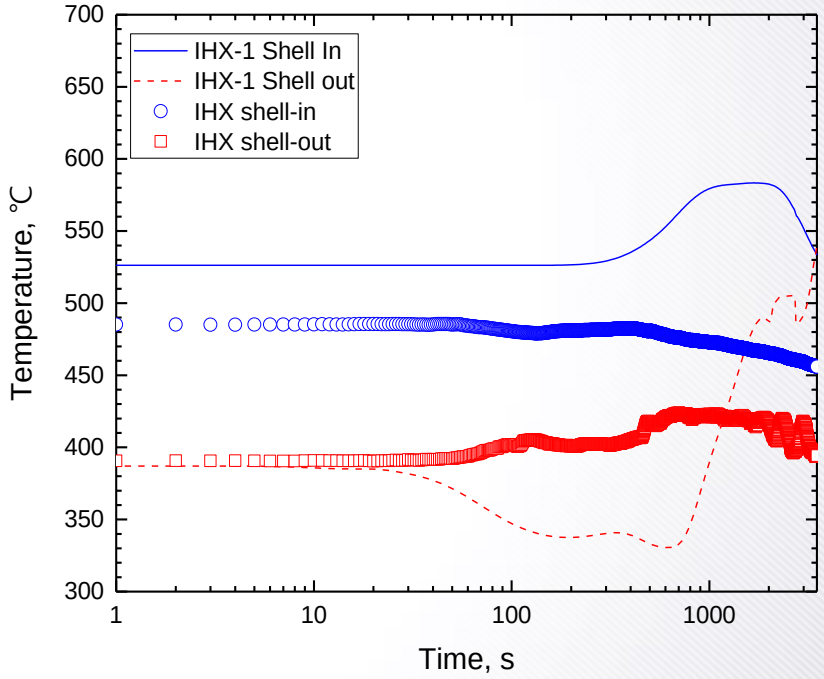
IHX Shell-side Temperature Trend

- Large difference in trend
- Difference 1
  - Shell inlet temp is lower than core outlet

    → Unexpected heat loss
- Difference 2
  - ΔT is much smaller

    → No flowrate in code, Yes flowrate in real

    ※ No credit for safety analysis of reactor



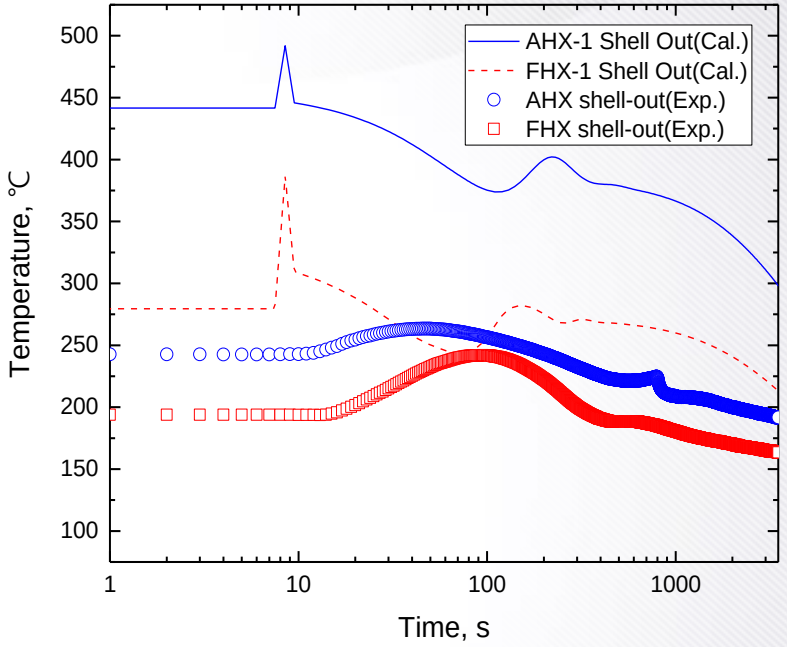
IHX Temperature Comparison

Comparison btw Experiment & Code

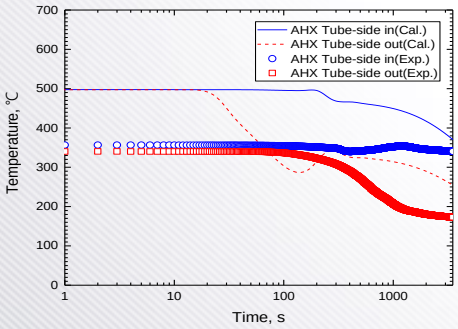
Heat Removal through AHX & FHX

- Smaller heat removal rate but similar trend
- Difference
  - Smaller ΔT & smaller flowrate

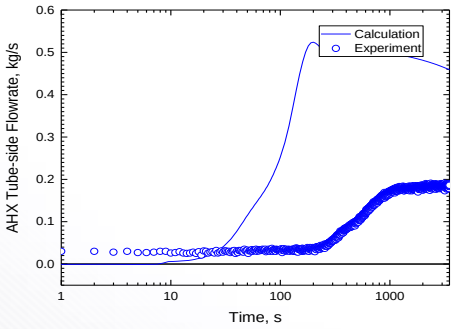
→ Less heat for removal due to heat loss



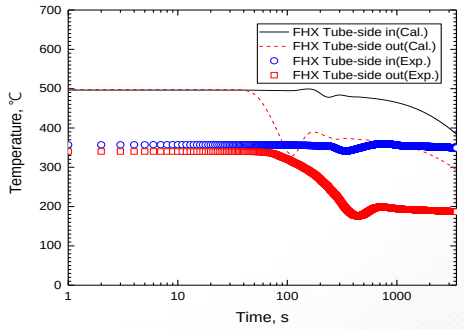
Air Temperature Comparison



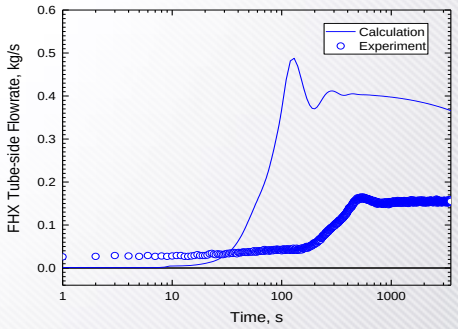
AHX Sodium Temp



AHX Sodium Flow



FHX Sodium Temp



FHX Sodium Flow

Conclusion

- LOF transient experiment successfully conducted
  - 1 ADHRS and 1 PDHRS working condition was tested
  - Experiment results were compared with code calculation
- Flowmeter problem was found and will be re-calibrated
  - Over-measurement will need to be fixed
- Unexpected heat loss was identified
  - It will be addressed with further study

Thank you