DHRS Cooling Effect Analysis of STELLA-2 using MARS-LMR

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CONTENTS

01 Introduction

STELLA Program Status

- Construction of large-scale integral effect test facility completed
- STELLA-2 facility is now operating and producing various experiment data
- Focus is on the DHRS performance

Purpose

- To explore the limit and boundary condition of the facility
- To analyze the system behavior before actual experiment

Scope

- DHRS cooling effect was analyzed using MARS-LMR code
- Scope of this study bounds in observation of the phenomena and discussion

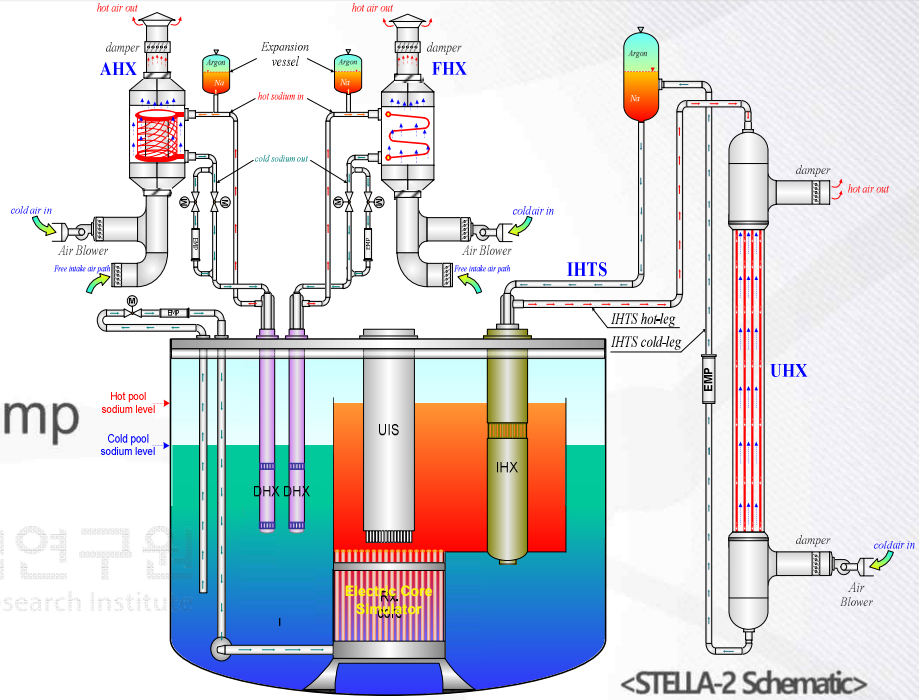
02 STELLA-2 Facility

General Description

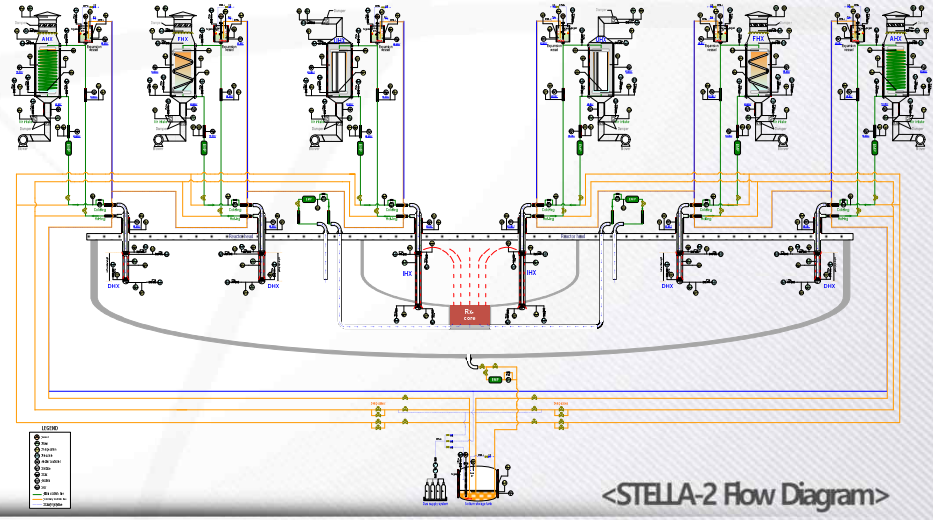
- Conserves the transient behavior
- Includes all major components, except

  (1) Nuclear fuel, (2) SG, (3) Mechanical pump

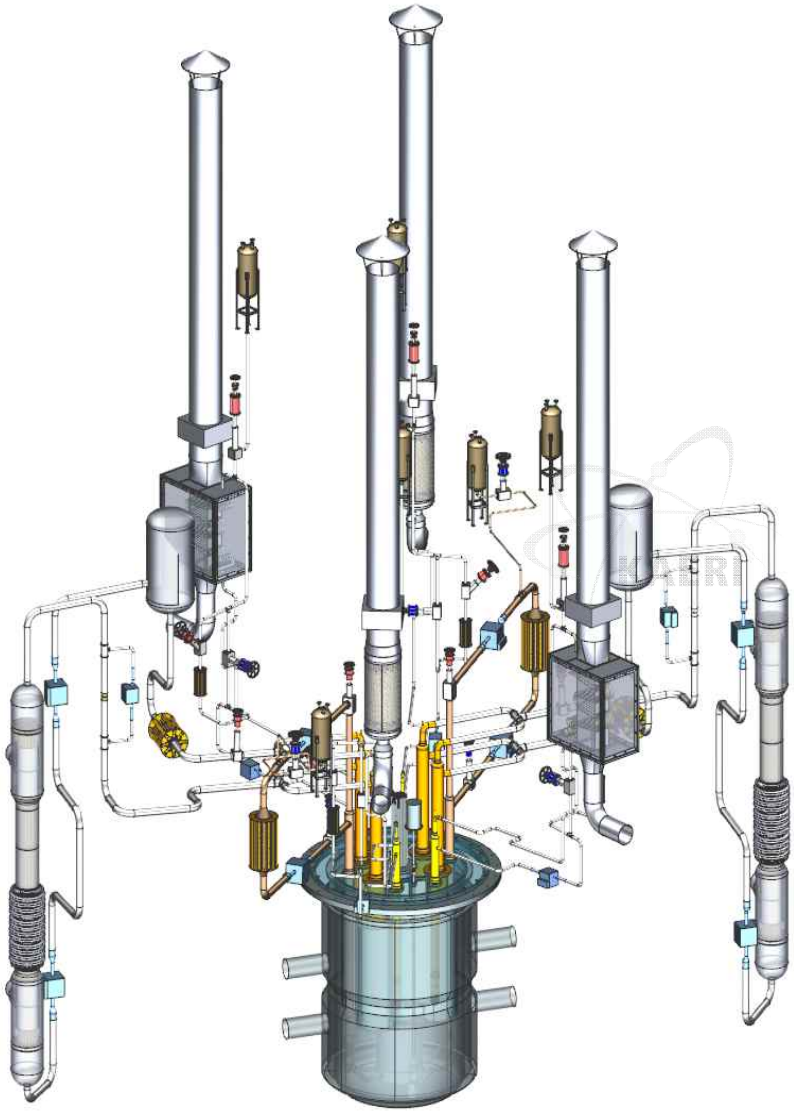
- Scale : 1/5 in length, 1/1 aspect ratio
- Sodium inventory : ~15 tons
- Design temp : 600℃
- Design press : 5 bar
- Total electric power : ~3 MW



<STELLA-2 Schematic>


<STELLA-2 Flow Diagram>

02 STELLA-2 Facility



<STELLA-2 시험 장치 3D 모델링>

<STELLA-2 시험 장치 전경>

03 MARS-LMR Analysis

Representative DBE : LOF + LOOP

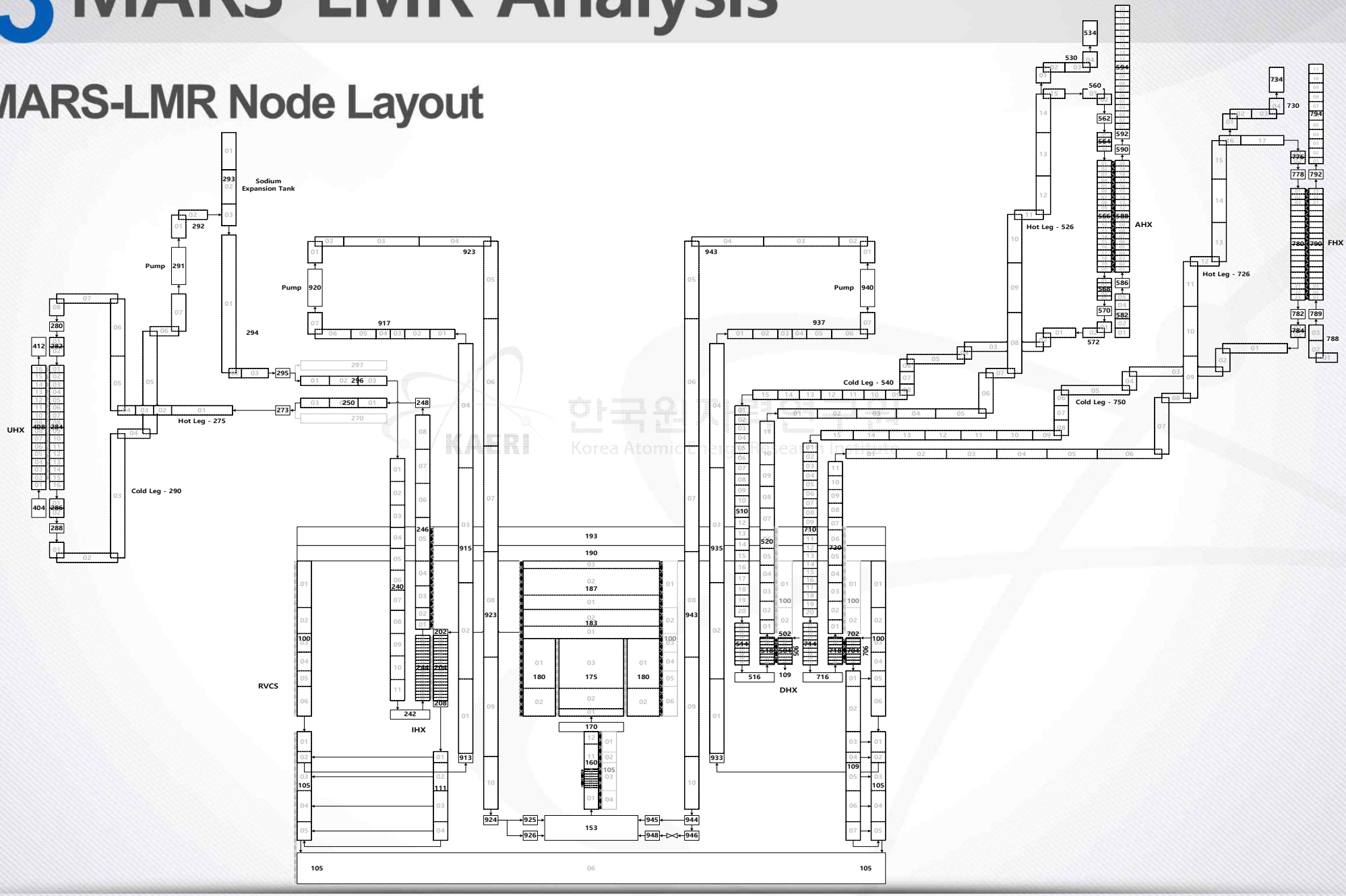
- Loss of Flow (LOF) occurs when all primary pump power is lost
- Results in immediate temperature rise of coolant
- One of the main reason is Loss of Off-site Power (LOOP)

Assumptions

- Steady-state point set to match the temperature distribution
- Transient starts with rapidly reducing the primary flow
- Intermediate loop flow also stops
- Core starts to follow decay heat curve
- Each one of HXs in ADHRS and PDHRS is not working
- Calculation done up to ~50,000 sec

03 MARS-LMR Analysis

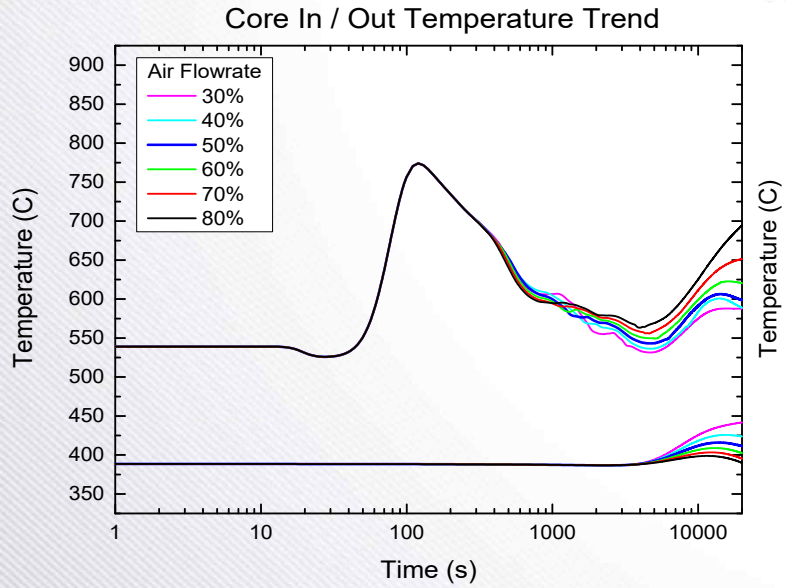
MARS-LMR Node Layout

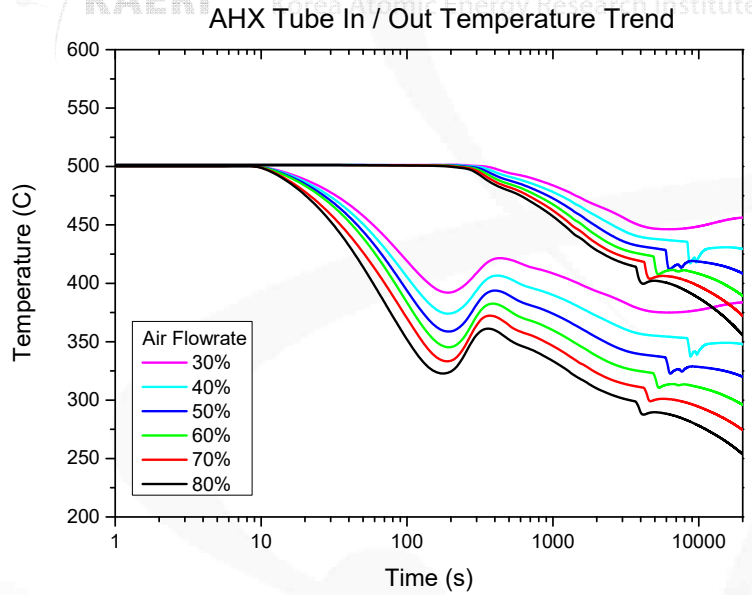


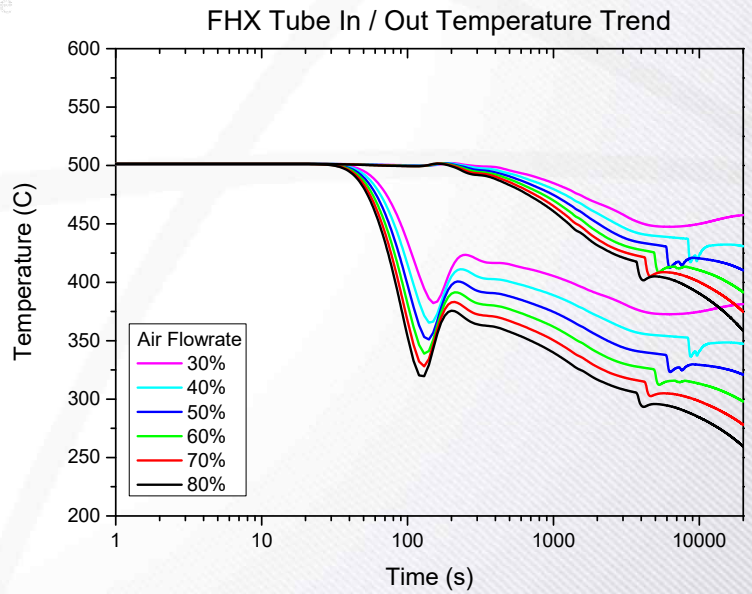
04 Results and Discussion

Temperature Trend

- Air flowrate of passive & active HXs controlled : 30 ~ 80 %
- Air flow ↑ ⇨ core in/out ΔT ↑ ⇨ core out T ↑
- Air flow ↑ ⇨ sodium T in DHRS ↓ ⇨ HX tube in/out ΔT ↑



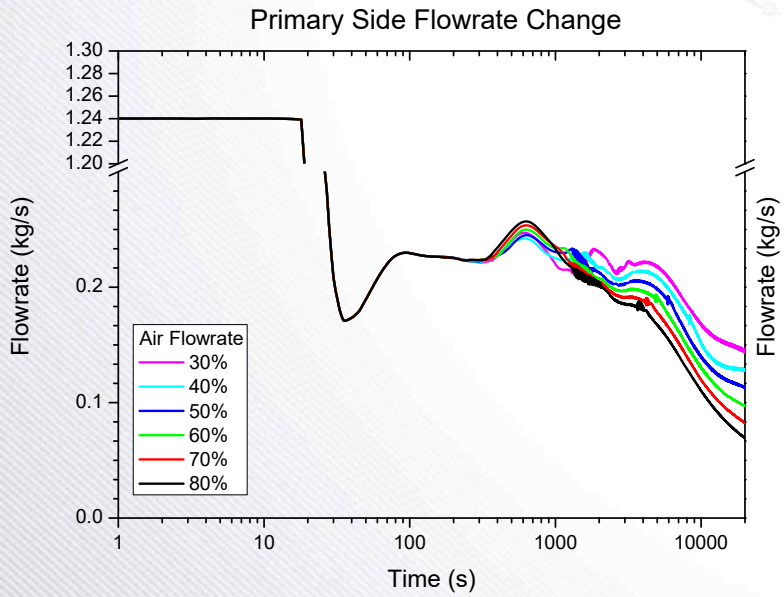


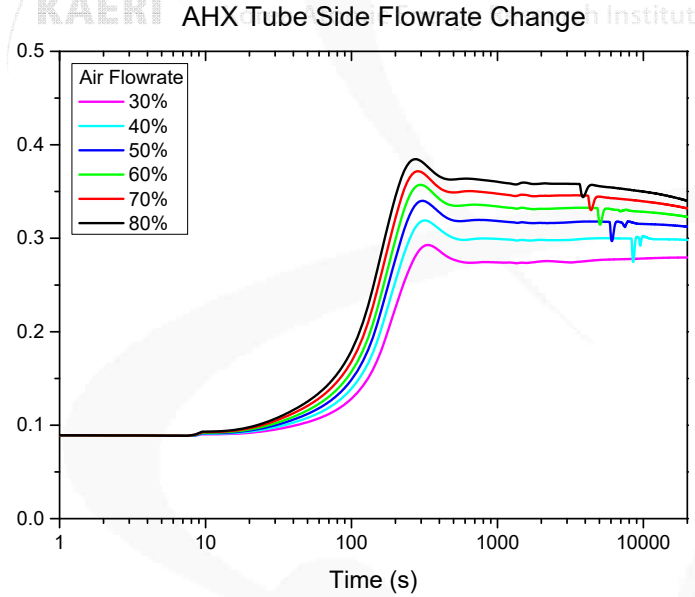


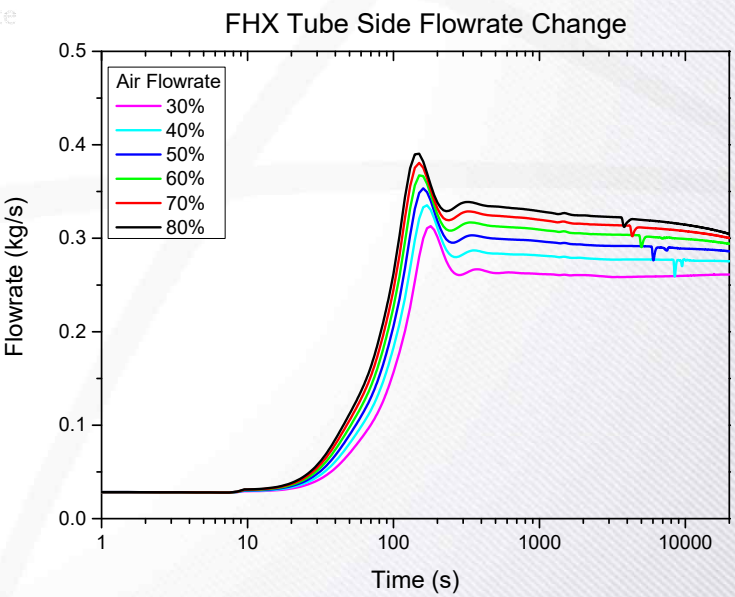
04 Results and Discussion

Flowrate Trend

- Air flowrate of passive & active HXs controlled : 30 ~ 80 %
- Air flow ↑ ⇨ natural circulation sodium(primary side) flow ↓
- Air flow ↑ ⇨ sodium flow in DHRS ↑







04 Results and Discussion

Discussion

- Inconsistent with expectation on primary side
- Air flow ↑ ⇨ sodium flow ↓ ⇨ core out T ↑ (???)

- Cause of inconsistency
  - Thermal stratification at cold pool

    From DHX shell out to the bottom of the pool
  - Axial conduction of coolant

    High thermal conductivity of liquid sodium
  - 1D vs 3D

    Node layout in code versus 3D mixing in real

05 Conclusion

- **STELLA-2 is ready for various transient experiments are on-going**
- **DHRS cooling effect is one of the most important aspect**
  - Observation by controlling the air flowrate of final HXs
  - The analysis results are inconsistent with the expectation
  - Cause of inconsistency
    - Thermal stratification
    - Axial conduction
    - 3D mixing effect
  - For verification, the experiment data will be needed

06 Reference

[1] J. Eoh et al., “Computer Codes V&V Tests with a Large-Scale Sodium Thermal-Hydraulic Test Facility (STELLA),” American Nuclear Society 2016 Annual Meeting, New Orleans, US, June 12-16, 2016.

[2] J. Lee et al., “Design evaluation of large-scale sodium integral effect test facility (STELLA-2) using MARS-LMR”, Annals of Nuclear Energy, Vol. 120, pp.845-856, 2018.

[3] J. Eoh, “Engineering Design of Sodium Thermal-hydraulic Integral Effect Test Facility (STELLA-2)”, KAERI SFR Design Report, SFR-720-TF-462-002Rev.00, 2015.