Profile SFR-89

SELFA

Republic of KOREA

GENERAL INFORMATION

NAME OF THE FACILITY	SELFA
ACRONYM	Sodium thermal-hydraulic Experiment Loop for Finned-tube sodium-to-Air heat exchanger
COOLANT(S) OF THE FACILITY	Liquid sodium
LOCATION (address):	SFR NSSS Design Division, Korea Atomic Energy Research Institute, 989-111 Daedeok-daero, Yuseong-gu, Daejeon, Korea
OPERATOR	KAERI
CONTACT PERSON (name, address, institute, function, telephone, email):	Hyungmo Kim, 989-111 Daedeok-daero, Yuseong-gu, Daejeon, Korea, KAERI, Fast Reactor Demonstration Division, Tel. +82 42 868 2221, hyungmo@kaeri.re.kr

STATUS OF THE FACILITY In operation

Start of operation (date): 2015

MAIN RESEARCH FIELD(S)

- ☐ Zero power facility for V&V and licensing purposes
- ☐ Design Basis Accidents (DBA) and Design Extended Conditions (DEC)
- ☒ Thermal-hydraulics
- ☐ Coolant chemistry
- ☐ Materials
- ☒ Systems and components
- ☐ Instrumentation & ISI&R

TECHNICAL DESCRIPTION

Description of the facility

As a part of STELLA program extension, a test loop for FHX was separately constructed and the experiments was conducted in 2016. The main target is FHX in PGSFR and it is aimed for V&V of design code and providing feedback on safety analysis code.

The SELFA facility consists of a main test loop, and a gas supply and related auxiliary systems. The sodium-side (tube-side) main components of this facility are the model heat exchanger (M-FHX), an electromagnetic pump, an electric loop heater, flow meters, an expansion tank, and a sodium storage tank. The air-side (shell-side) key components are a blower and dampers. The designed maximum temperature of the facility is 500 °C, and the designed power capacity of the main heater is 650 kW. The pipe diameter of the whole facility is 2-inch of Sch20, and the expected operation flow rates are from 0.99 kg/s to 4.38 kg/s in the tube-side and from 0.12 kg/s to 3.4 kg/s in the shell-side. The maximum available flow rates of the electromagnetic pump and the blower are around 6 kg/s and around 5 kg/s with margins, respectively. Appropriate instruments have been also employed for measuring flow rates, temperatures, and pressure differences.

The reference FHX (in PGSFR), which has 2.5 MWt thermal duty per unit, mainly consists of total 96 tubes with helical-fins. It has four-pass serpentine (or M-shape) tubes with a staggered tube arrangement to enhance heat transfer performance. Basically we have employed volume-scale approach to make scaled-down design of the model FHX unit. That is, the Model FHX unit has the same length and height scale with the prototype FHX, but the reduced power scale with 1 over 8 by reducing the number of tubes columns (i.e., total 12 tubes in 4 columns). Table 1 represents the comparison between the reference FHX and M-FHX based on the design point. The overall scale ratio of the test heat exchanger was determined to be unity for the height (or length) and 1/8 for power level (or volume). The material of the tube is changed from Mod.9Cr-1Mo to STS304 for manufacturing convenience. Fin pitch and finned tube length is slightly reduced, but it allows the preservation of the frontal area and *Re* condition.

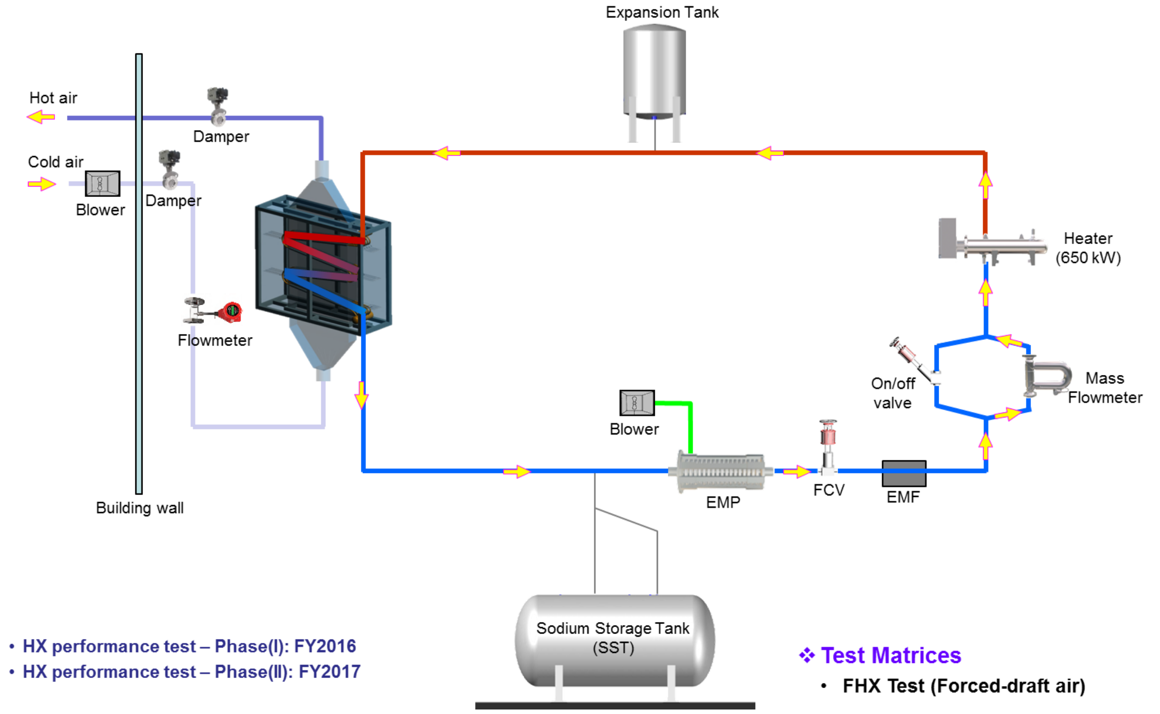
Table 1 Comparison between the reference FHX and M-FHX based on the design point

Design parameters		PGSFR FHX	SELFA M-FHX	Ratio
Thermal duty (MWt)		2.5	0.3125	1/8
No. of tube columns		32	4	1/8
No. of tubes		96	12	1/8
Tube arrangement(4-pass serpentine), P_L & P_T		2.05 & 2.5	2.05 & 2.5	P
Tube material		Mod.9Cr-1Mo	STS304	-
Bare tube OD/ID (mm)		34.0 / 30.7	34.0 / 30.7	P
Thickness (mm)		1.65	1.65	P
Finned tube length (Total, m)		8.000	7.722	0.9652
Fin height (mm)		15.0	15.0	P
Fin thickness(width, mm)		1.5	1.5	P
Tube inclined angle (degree)		7.2	7.2	1/1
No. of fin (per unit length, m)		152	157.48	0.9652
Spacing between Fins (mm)		5.08	4.85	0.9547
Total heat transfer area with Fin surface (m^2)		656.34	82.04	1/8
Total number of fins per single tube (ea)		1216	1216	P
Flow region size (WxD, m)		1.984 x 2.763	1.984 x 0.3825	-
Tube-side (Sodium) (@Design point)	Flow rate (kg/sec)	17.54	2.19	0.1249
	Inlet/Outlet temp. (℃)	334.6/226.2	335/224.18	-
Shell-side (Air) (@Design point)	Flow rate (kg/sec)	13.63	1.70	0.1247
	Inlet/Outlet temp. (℃)	40.0/226.2	20.0/213.9	-
				P: Preserved

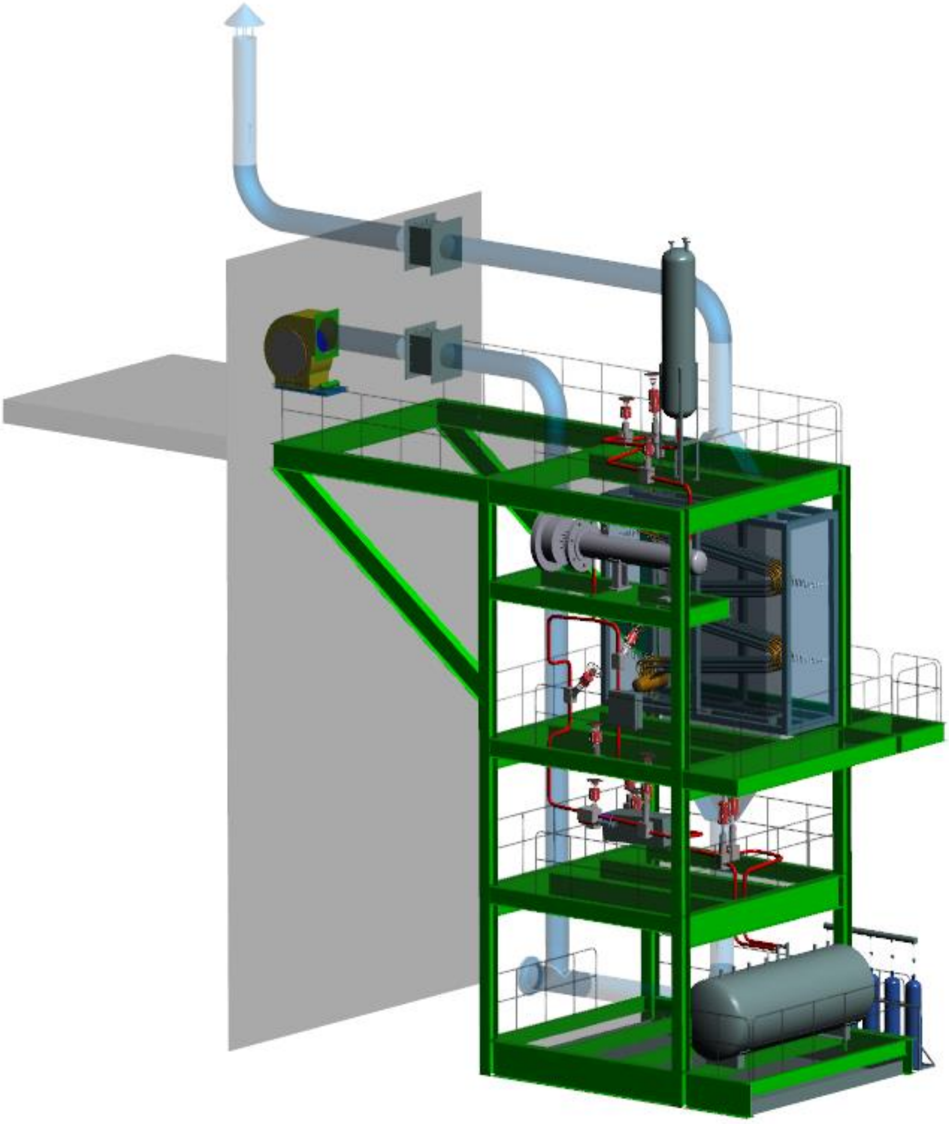
Acceptance of radioactive material

No

Scheme/diagram



3D drawing/photo



Parameters table

Coolant inventory	1.5 tons at maximum
Power	650 kW
Test Sections	
TS #1 (FHX)	*Characteristic dimensions* 3.5 x 1.2 x 3.0 (m)
	Static/dynamic experiment Dynamic
	Temperature range in the test section (Delta T) 0 ~ 250 ℃ (Shell-side, Air), 100 ~ 350 ℃ (Tube-side, Na)
	Operating pressure and design pressure Operating Pressure: 10 kPa ~ 200 kPa Design pressure: ~0.5 MPa
	Flow range (mass, velocity, etc.) 0 ~ 2 kg/s (Shell-side, Air), 0 ~ 3 kg/s (Tube-side, Na)

Coolant chemistry measurement and control (active or not, measured parameters)	For impurities control, a purification loop in other facility is shared.
Instrumentation	Thermocouples, 2 types of flowmeter (Coriolis, EMF), pressure transducer, leak detector, 2 types of level gauge (contact, weight pendulum)

COMPLETED EXPERIMENTAL CAMPAIGNS: MAIN RESULTS AND ACHIEVEMENTS

The main tests were completed in 2016 for heat exchanger V&V. The experiment results were in good agreement with the estimation of design code (FHXSA). The deviation was ~13.5%.

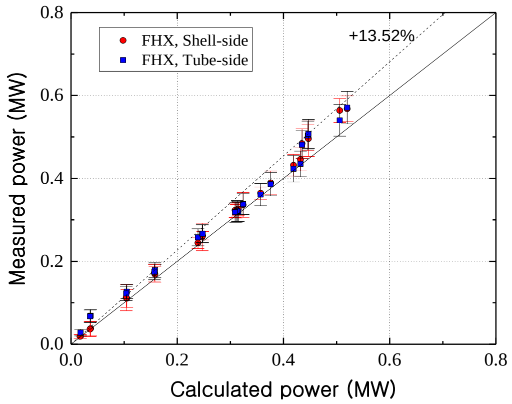


Figure 1 FHX test results

The experiment data was used as a base for design code V&V as well as the Safety Analysis Report for Prototype Gen IV Sodium-cooled Fast Reactor (PGSFR) designed by KAERI. The target codes were FHXSA and MARS-LMR.

PLANNED EXPERIMENTS (including time schedule)

Natural circulation experiment to verify the heat removal capacity is planned in near future (not specified yet).

TRAINING ACTIVITIES

Training activities can be arranged under the KAERI supervision.

REFERENCES (*specification of availability and language*)

- KIM, H. et al., "Design Features of the Separate Effect Test Facility for a Forced-Draft Sodium-to-Air Heat Exchanger with Helical Finned Tubes", Transactions of the Korean Nuclear Society Autumn Meeting, Gyeongju, Korea, Oct. 29-30 (2015).
- KIM, H. et al., "Design Evaluation of Thermal-hydraulic Test Facility for a Finned-tube Sodium-to-Air Heat Exchanger", Transactions of the Korean Nuclear Society Spring Meeting, Jeju, Korea, May 11-13 (2016).
- KIM, H. et al., "Design and Preliminary Evaluation of the Separate Effect Test Facility for a Sodium-to-Air Heat Exchanger with Helical Finned Tubes", 24th International Conference on Nuclear Engineering, Charlotte, NC, USA, June 26-30 (2016).

- Kim, H. et al., “Heat Transfer Performance Test for a Sodium-to-Air Heat Exchanger with Inclinned Finned-Tube Banks”, International Conference on Fast Reactors and Related Fuel Cycles (FR17), Yekaterinburg, Russian Federation, 26-29 June (2017).