Basic Design of Experimental Facility for Measuring Pressure Drop of IHX in a SFR

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1. Introduction

The conceptual design of the Prototype gen-IV SFR (PGSFR) with a 150 MWe capacity was commenced in 2012 through the national long-term R&D program by KAERI. Then, PGSFR is now being designed with the defense in depth concept with active, passive and inherent safety features to acquire design approval for PGSFR from the Korean regulatory authority by 2020.

PGSFR is a sodium-cooled pool-type fast reactor with all primary components including the primary heat transport system (PHTS) pumps and IHXs are located inside a sodium pool. Fig. 1 shows the conceptual design of the PGSFR. The heat produced due to fission in the core is transported by primary sodium to secondary sodium in a sodium to sodium intermediate heat exchanger (IHX), which in turn is transferred to water in a steam generator (SG).

This paper introduces the scaling analysis of the experimental facility for measuring the pressure drop in the shell-side of the IHX in the simulated PGSFR test facility.

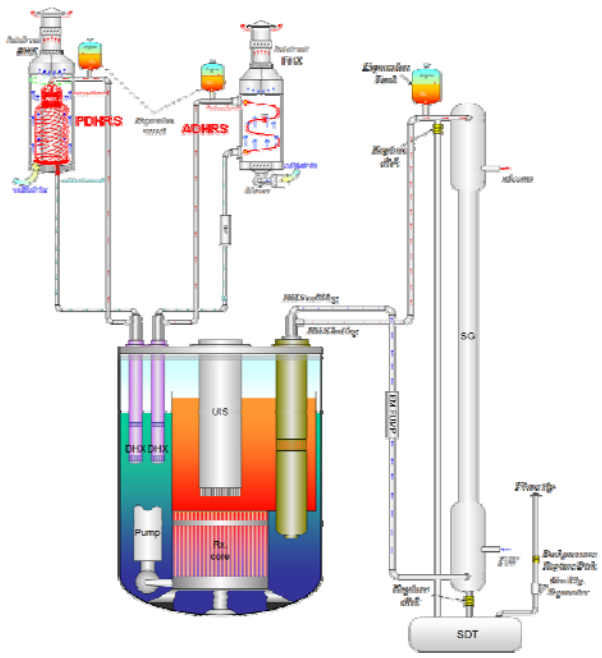

Fig. 1 Conceptual design of PGSFR

2. Design of the IHX in PGSFR

The intermediate heat exchanger (IHX) is a shell-and-tube type heat exchanger with a counter-current flow heat exchanging mechanism. The unit has a vertical orientation inside the reactor vessel, and its design arrangement properly provides downward and upward flows of the primary and intermediate sodium, respectively. A total of four cylindrical-shape IHXs are installed in the primary heat transport system along with two primary pumps.

Primary sodium from the hot sodium pool enters the shell-side of the IHX through the inlet nozzle located below the upper tube sheet. Primary sodium flows downward along the heat transfer tubes and total five grid plates are installed for tube support in the primary sodium flow path. After heat exchanging inside the IHX, primary sodium enters the spherical annular channel enveloping the lower channel head and is discharged into the cold pool. During normal plant operation, the difference in sodium level between the hot and cold pools is caused by the pressure drop at the shell-side flow path. Fig. 2 shows the schematic design of a IHX in PGSFR.

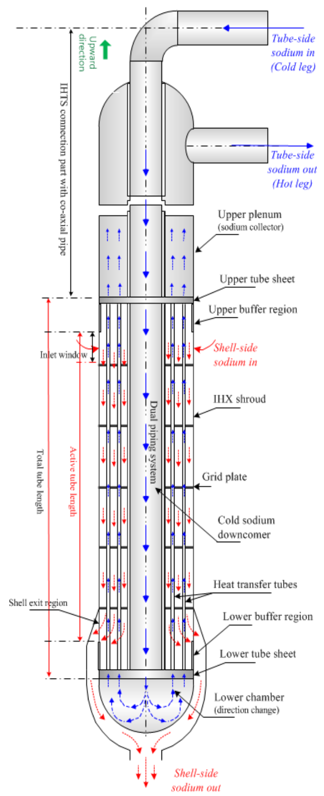

Fig. 2 Design of the IHX in PGSFR

The pressure drop measurements are made for a single flow channel composed of circular rod bundles, which have a specific pitch-to-diameter (P/d) ratio with a triangular pitch layout, as shown in Fig. 3.

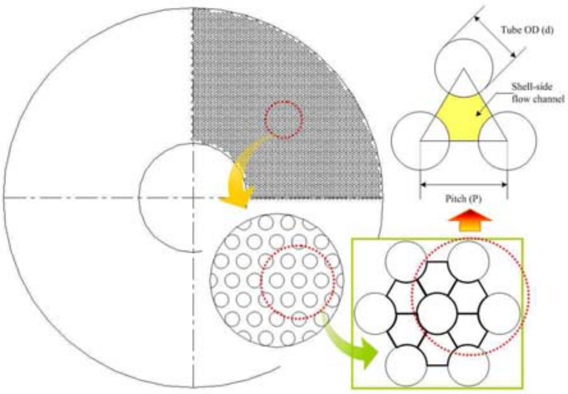

Fig. 3 Flow channel model of IHX

3. Scaling analysis of WEIPA

An experimental facility, called WEIPA (Water-mockup Experimental facility for IHX Pressure drop Assessment), has been designed to measure the pressure drop for a prediction of pressure loss in the shell-side of the IHX in PGSFR. Its height is preserved with IHX of PGSFR and its area and volume are scaled down to 1/40 compared with the IHX of PGSFR.

4. Test loop of WEIPA

The test loop of WEIPA consists of the test section, storage tank, pump, chiller, heater, and flow meter. Fig. 4 shows a schematic drawing of the test loop (WEIPA).

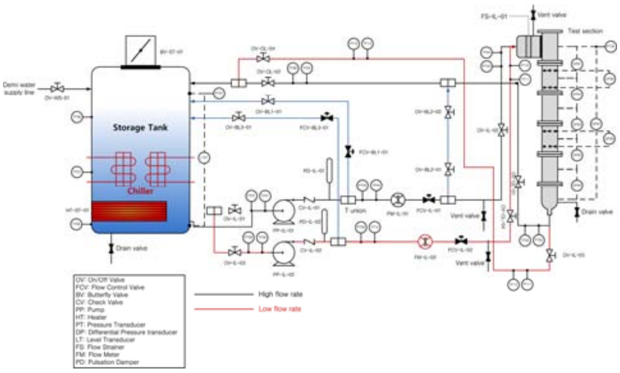

Fig. 4 Schematic drawing of the test loop (WEIPA)

5. Test section of WEIPA

The working fluid of the WEIPA facility is water instead of liquid sodium. The diameter, thickness, pitch, and tube arrangement of the WEIPA are the same with those of the IHX in PGSFR, but the test section is designed with the part of IHX in PGSFR (Fig. 5). The flow area of the test section is designed as a 1/40 scaled rectangular shape. In a flow area with a rectangular shape, three rows of tubes (a total of 34 tubes as shown in Fig. 6) are installed.

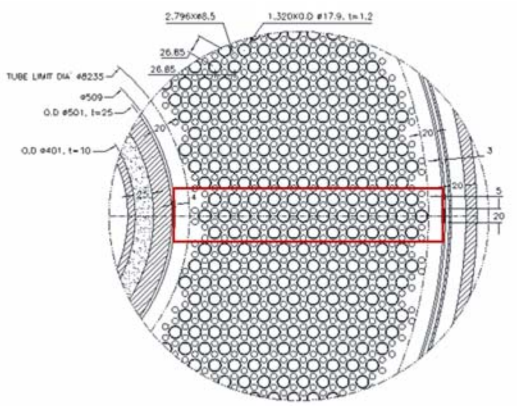

Fig. 5 Designed test section of the part of IHX

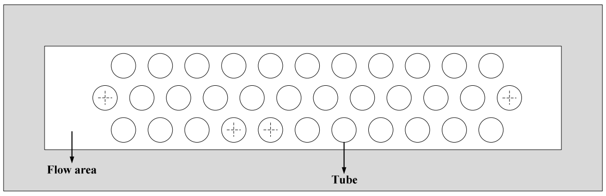

Fig. 6 Tubes arranged in the flow area (test section)

In the flow path of the test section, five grid plates are installed to support tubes like the IHX in PGSFR. The test section must be able to simulate the flow area of the IHX in PGSFR. Fig. 6 shows that the grid plates are installed at the inlet and out let of the test section.

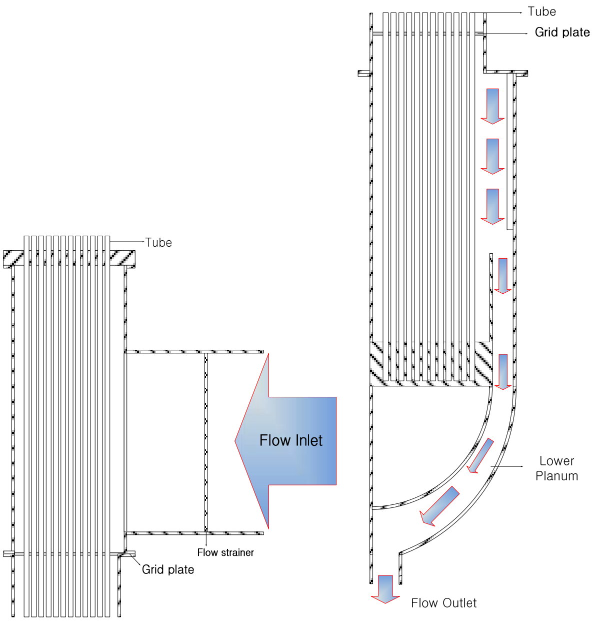

Fig. 6 Grid plates installed at the flow inlet and outlet

5. Conclusions

Basic design of the IHX flow characteristic test facility, WEIPA was conducted based on the three-level scaling methodology in order to preserve the flow characteristics of the IHX in PGSFR. This test facility is intended to measure a high precision pressure drop at the shell-side of the IHX. This paper describes the aspects of the current design features of the IHX in PGSFR, scaling and basic design features of the facility. The test results from the WEIPA facility will be used to validate a computer design code of SHXSA and quantify the uncertainties of the correlations implemented in the design code.

AKNOWLEDGEMENT

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