Transactions of the Korean Nuclear Society Spring Meeting
Taebaek, Korea, May 26-27, 2011

Scoping Test of a Water Scaled Model for the Thermal Hydraulic Study of 600MWe-SFR

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1. Introduction

KAERI has been developing a pool-type Sodium-cooled Fast Reactor(SFR). In order to extrapolate a thermal hydraulic phenomena in a large sodium reactor, the thermal hydraulics phenomena is under investigation in a 1/10 water scaled model for the KALIMER-600., As a scoping test of the transparent water scaled facility, the flow distribution and local pressure loss were preliminarily measured as well as a primary system flow rate.

2. Experimental Facility and Test Results

Figure 1 shows the schematics of KALIMER-600, which is a pool-type Sodium-cooled Fast Reactor (SFR) with a 600MWe capacity.

To design a scaled water reactor model, similarities between 1/10 scaled water model and KALIMER-600 reactor should be an exact match. For natural circulation phenomena, it was necessary to match scaling parameters such as Richardson number, and Euler number on the basis of geometrical similarity. Figure 2 shows major scaling parameters for this study and schematics of scaled reactor vessel.

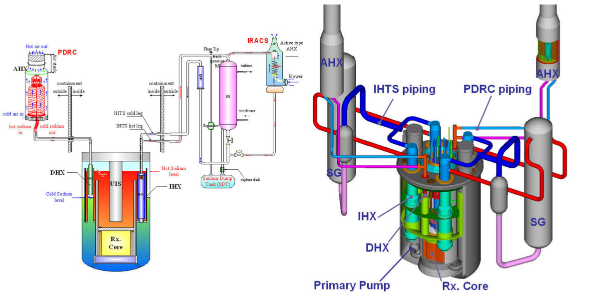

Figure 1. Schematics of KALIMER-600 reactor system

Parameter	Prototype	Scaled-Model	Prototype	Scaled-Model
Reference reactor	KALIMER-600	1/10	SAFR/ANL	1/11.2
RV length [m]	18.5	1.85	14.6	1.304
RV diameter [m]	11.41	1.14	11.9	1.062
Power [MW]	1523.6	0.560	900	0.275
∆T across core [°C]	155.0	14.59	152.8	15.7
Volume flow ratio		1/999.1		1/1415.9
Velocity ratio		1/10		1/11.3
Time ratio		1.0		1.0
Richardson # ratio		1.0		1.0
Friction # ratio		(1.0)		1.0

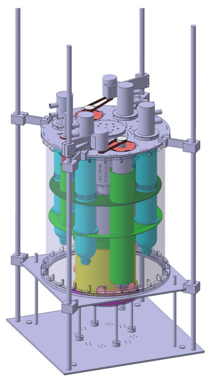

Figure 2. Major scaling parameters and schematics of scaled reactor vessel

Figure 3 shows the schematic diagrams of the experimental facility. The intermediate heat transport system and passive decay heat removal circuit of the KALIMER-600 were replaced by two chiller systems.

The scaled transparent reactor vessel is installed in a separate room on the second floor since its temperature could be controlled to reduce the heat loss from the reactor vessel. In order to obtain correct measurements and decrease error from light and vibration, discrete room is installed. De-ionized water is used for working fluid. Outside the room, the water treatment system is placed to supply de-ionized water and chillers are also placed.

Figure 4 shows the 1/10 scaled RV test section. All components are scaled down to 1/10 exactly if possible. All components except the reactor head and bottom of reactor vessel are made of the transparent Plexiglas and Polycarbonate for flow visualization and measurement using optical methods. The reactor vessel was made by a transparent 25mm Plexiglas.

The model consists of four IHX(Intermediate Heat Exchanger) made by stainless steel, two DHX(Decay Heat Exchanger) and two primary pumps. Instead of nuclear fuel rods and reflectors, a total of 69 electric heaters (3/4"-1.5kW) and a total of 68 dummy heaters are mounted in the core region, and a total of 104 dummy reflectors are also installed in the reflector region. The heaters are controlled by a total of 16 groups. For a temperature control, a sheathed thermocouple is attached on the each heater surface.

The IHX and DHX heat exchangers are connected to two cooling systems, which has a water circulation loop and a refrigerant cycle, respectively. The performance of PHTS pump can be adjusted by the inverter with various working conditions.

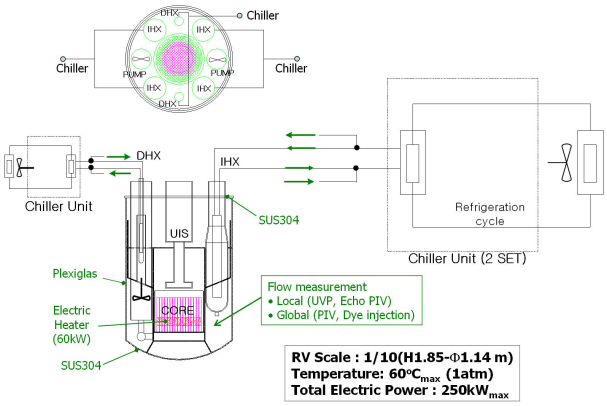

Figure 3. Schematics of test facility

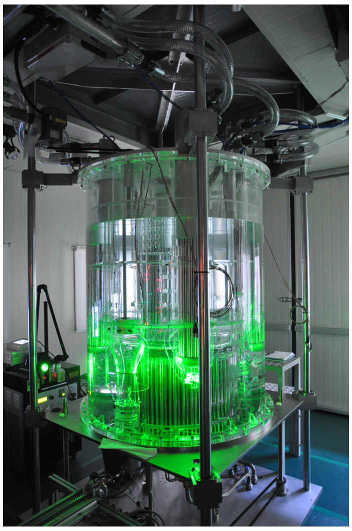

Figure 4. Photo of RV test section

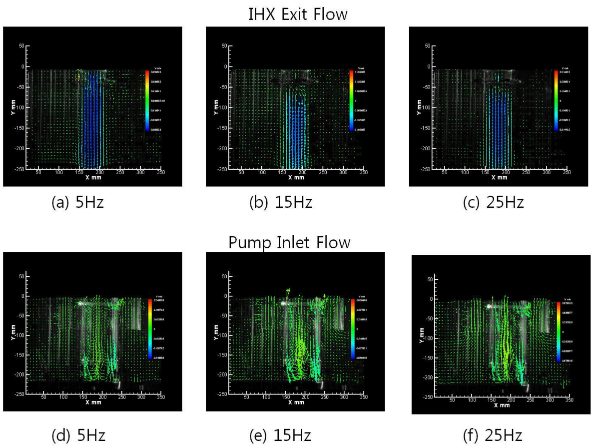

Figure 5. Flow field in the IHX exit and pump inlet

The primary flow rate is measured by a Bi-Directional Flow Tube (BDFT) which is mounted on the downstream of pump flow path in the vicinity of the inlet plenum. The pressure drop in each component is measure by SMART-type Rosemount DP-meter. The velocity field and temperature field are measured by PIV(Particle Image Velocimetry) and more than 300 T-type thermocouples, respectively. For PIV stereoscopic image processing, a 250mJ dual Nd-Yag Laser and two 2M pixel CCD cameras were prepared.

Figure 5~7 show the results of the scoping test in the isothermal condition to check an operability of experimental facility. Figure 5 shows the flow distributions measured by PIV flow visualization in the IHX exit and PHTS pump inlet with a pump rotation. Figure 6 is the PHTS flow rate calculated by the mean velocity and the given flow area. Figure 7 shows the pressure drop in the PHTS pump downstream between the propeller exit and the inlet plenum inlet. The results show a possibility of the facility for a TH experiments to some extent.

On the basis of a scoping test results, the macroscopic flow and temperature field data has been obtained in the low flow and velocity condition as well as a pressure drop coefficient within the 2011 fiscal year.

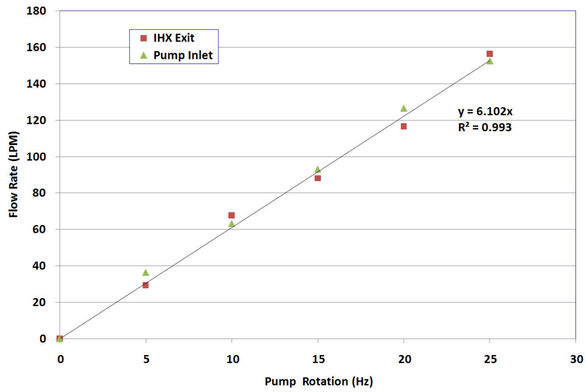

Figure 6. PHTS Flow rate measured by PIV method

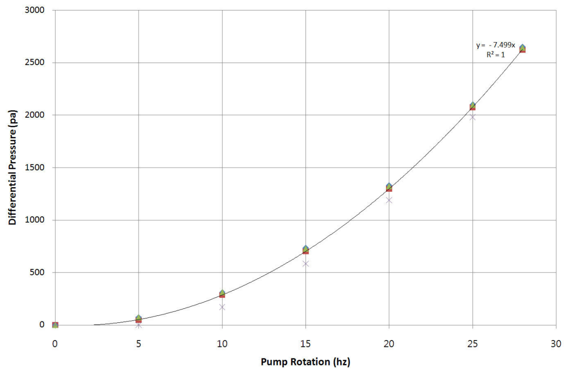

Figure 7. Pressure drop in the PHTS pump downstream

3. Summary

In order to extrapolate thermal hydraulic condition in a large sodium reactor KALIMER-600, the thermal hydraulics phenomena is under investigation in a 1/10 water scaled reactor model instead of sodium model. For the design of a KALIMER-600 water stimulant model, an installation of the experimental facility was finished. A scoping test has been conducted in the isothermal condition and the results show a good possibility of the facility for a TH experiments.

ACKNOWLEDGMENTS

This study was performed under the Mid- and Long-term Nuclear R&D Program sponsored by the MEST of the Korean Government.

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