Development 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) with a 600MWe electric generation capacity. For a SFR development, one of the main topics is an enhancement of the reactor system safety. Thus, the large sodium experimental facility will be designed to evaluate the reactor safety and component performance. Before a large sodium test, a scaled water model test will be conducted due to several benefits. In this study, the thermal hydraulic behavior will be investigated with a 1/10 scaled reactor vessel model for the KALIMER-600 reactor. The scaled water model facility will be operated at around 30°C water condition from June 2010, which was made by a transparent Plexiglas reactor vessel model. In this paper, the installation status will be described along with a scaling analysis.

2. Scale analysis for water similitude

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

Table 1. Major scaling parameters

Parameter	KALIMER-600	Water model
RV length[m]	18.5	1.85
RV diameter[m]	11.41	1.14
Power [MW]	1523.6	0.56 (×10%)
△T across core	155.0	14.59
Ri ratio	-	1.0
Velocity ratio	-	0.1
Time ratio		1.0

Table 2. Properties of Water and Liquid Sodium

			Water	Sodium
Temperature	T	[°C]	30	467.5
Specific volume	ν	[m³/kg]	0.001004	0.001190
Density	ρ	[kg/m³]	995.7	840.1
Specific heat	Cp	[J/kg-K]	4179.8	1269.4
Thermal conductivity	κ	[W/m-K]	0.6155	69.75
Viscosity	μ	[Pa-s]	0.000797	0.000263
Thermal expansion coefficient	β	[1/K]	0.000303	0.000285
Thermal diffusivity	α	[m²/s]	1.48E-07	6.54E-05
Prandtl number	Pr	[-]	5.4	0.005

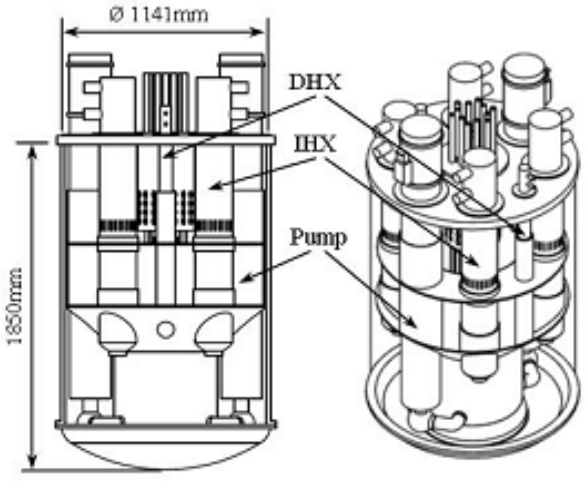

Figure 1. 1/10 scaled down KALIMER-600 model

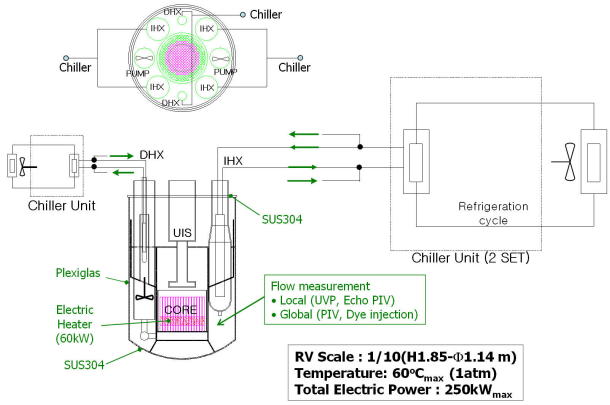

Figure 2. Schematics of test facility

3. Installation of Experimental facility

Figure 1 shows the geometries of 1/10 scaled KALIMER-600 water model. All components are scaled down to 1/10. The model consists of four IHX(Intermediate Heat Exchanger) made by stainless steel, two DHX(Decay Heat Exchanger) and two primary pumps. Total 100kW electric heaters (more than 56kW) wre used instead of nuclear fuel rod. The heaters will be controlled by a total of 16 groups. All components except reactor head and bottom of reactor vessel are made of transparent Plexiglas for flow visualization and measurement using optical methods. The reactor vessel was made by a transparent 20mm

Plexiglas. An each IHX and DHX was connected to a cooling system which has a refrigerant cycle, respectively. The performance of pump can be adjusted by inverter and controller with various working conditions. The primary flow rate is measured by Bi-Directional Flow Tube (BDFT) which is mounted on the downstream of pump flow path in the vicinity of inlet plenum.

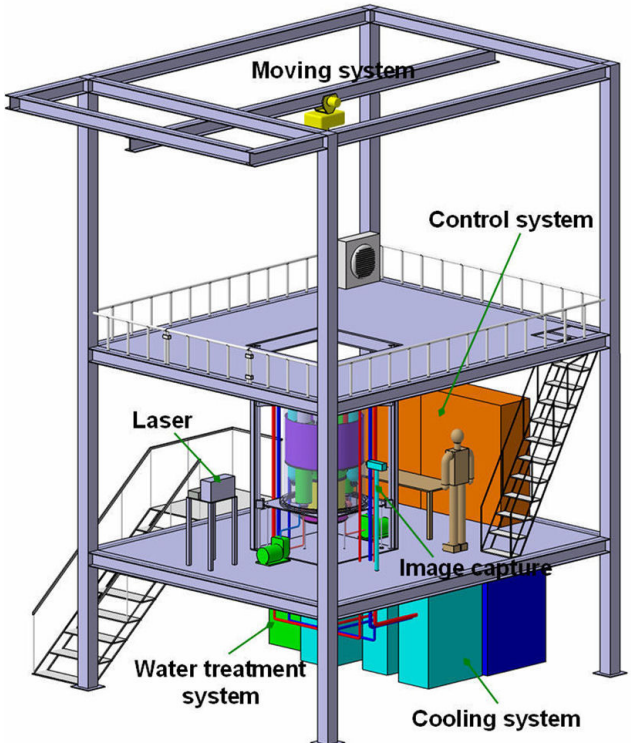

Figure 3. Bird's eye view of test facility

In order to correct measurement and decrease error from light and vibration, discrete room is installed. The de-ionized water was used for working fluid. The velocity field and temperature field are measured by PIV(Particle Image Velocimetry) and thermocouples, respectively. UVP(Ultrasound Velocity Profile) and Echo PIV will be used for the local flow measurement, and dye injection method for the macroscopic behaviors. The UVP sensor was also used to measure the primary flow rate.

The experimental setup is shown schematically in Figure 2 and Figure 3. The experimental facility was installed on the second floor room, its temperature could be controlled to reduce the heat loss from the reactor vessel. At the out of room, the water treatment system was placed to supply di-water and chillers were also placed.

Figure 4 shows the current status of the scaled water facility. All components are already installed in the test room. The preliminary operation is going to be finished within late of June 2010 after then signal connection and sensor calibration.

Figure 4. Photo of test facility

3. Summary

In order to extrapolate thermal hydraulic condition in a large sodium reactor KALIMER-600, the thermal hydraulics phenomena will be investigated in a 1/10 water scaled reactor model instead of sodium model. For the design of a KALIMER-600 water stimulant model, a scaling analysis was conducted. Installation of the experimental facility was nearly finished and preliminary thermal hydraulic test will be conducted within June 2010.

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