Preliminary Experiment 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). For a SFR development, one of the main topics is an enhancement of the reactor system safety. Thus, the large sodium experiments are planned to evaluate the reactor safety and component performance. Before a large sodium test, a scaled water model test had better be conducted due to several benefits. In this study, the thermal hydraulic behavior is investigated with a transparent 1/10 scaled reactor vessel model for the KALIMER-600 reactor. The scaled transparent water model facility is preliminarily operated at around 30°C water condition to check an operability of the experimental facility.

2. Installation of Experimental facility

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

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 shows major scaling parameters for this study.

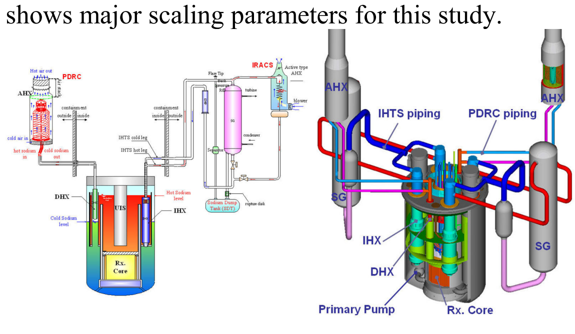

Figure 1. Schematics of KALIMER-600 reactor system

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

Figure 2 and 3 show 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 separated room on the second floor since its temperature could be controlled to reduce the heat loss from the reactor vessel. 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. At the out of room, the water treatment system was placed to supply a de-ionized water and chillers were also placed.

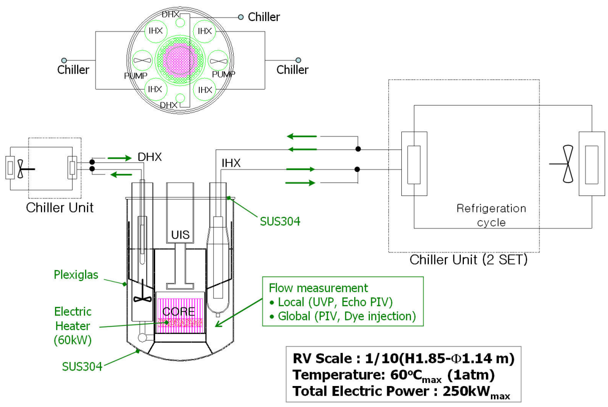

Figure 2. Schematics of test facility

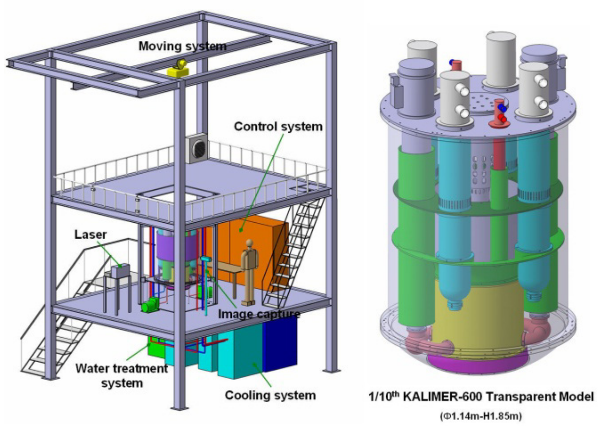

Figure 3. Bird's eye view of test facility

Figure 4 shows the photo 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. Instead of nuclear fuel rod and reflector, 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.

Figure 4. Photo of RV test section

All components except the reactor head and bottom of reactor vessel are made of the transparent Plexiglas and polycarbonate for the flow visualization and measurement using optical methods. The reactor vessel was made by a transparent 25mm Plexiglas.

The IHX and DHX heat exchangers are connected to two cooling systems in the Figure 5, which has a water circulation loop and a refrigerant cycle, respectively. The performance of PHTS 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. The PHTS flowrate was also measured by UVP(Ultrasound Velocity Profiling). 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 the PIV stereoscopic image processing, a 200mJ dual Nd-Yag laser and two 2M pixel CCD cameras were prepared.

UVP(Ultrasound Velocity Profiling) and Echo PIV are used for the local flow measurement, and dye injection(or microbubble injection) method for the macroscopic behaviors.

As a current status, an operability of experimental facility is under investigating after then interconnection of all experimental components. As a preliminary test, a macroscopic flow and temperature field data has been also obtaining in the low flow and velocity condition as well as a pressure drop coefficient within 2010 fiscal year.

Figure 5. Photo of chiller system

3. Summary

In order to extrapolate thermal hydraulic condition in a large sodium reactor KALIMER-600, the thermal hydraulics phenomena is under investigating 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 already finished and a preliminary thermal hydraulic test has been conducting within 2010 Fiscal year.

ACKNOWLEDGMENTS

This study was performed under the Mid- and Long-term Nuclear R&D Program sponsored by the Ministry of Education, Science and Technology of the Korean Government.

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