Isothermal Global Flow Investigation of the KALIMER-600 Water Scaled Model

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1. Introduction

In order to extrapolate a thermal hydraulic phenomena in the large sodium reactor, the thermal hydraulics phenomena is under investigation in a 1/10th water scaled model for the KALIMER-600. On the basis of the preliminary test [1], an isothermal global flow behavior was measured in the transparent water scaled facility with a flow visualization technique.

2. Experimental Facility and Test Results

The KALIMER-600 is a pool-type Sodium-cooled Fast Reactor (SFR) with a 600MWe generation capacity. Figure 1 shows the 1/10 scaled RV test section for the KARIMER-600 SFR. All components are geometrically scaled down to 1/10 exactly if possible. 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.

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 thickness Plexiglas. 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. De-ionized water is used for working fluid. The detailed specification of the experimental facility can be described in the reference [1]. The performance of PHTS pump can be adjusted by the inverter with various working conditions. The velocity field and temperature field are measured by PIV(Particle Image Velocimetry) and more than 300 T-type thermocouples, respectively. For a PIV image processing, a 250mJ dual pulsed Nd-Yag Laser and a 2M pixel CCD camera were prepared. The flow image was analyzed by the INSIGHT 3G software (TSI).

Figure 2 shows the PHTS flow rate measured by PIV method. The flow rate was calculated with the averaged velocity multiplied by the flow area in the PHTS pump inlet and IHX exit regions, respectively. For the PIV test, a total of 4 gram particles (40μm diameter, Silver coated hollow seed particles) were inserted in the RV water pool. Table 1 shows the time interval between dual pulses for a PIV image capturing with motor rotation. Laser pulse delay time and camera exposure time are 2000μs and 2400μs, respectively. The spatial resolutions of the PIV capturing are 159.68μm/pixel and 168.52μm/pixel for the IHX exit and pump inlet region, respectively. From the figure, the maximum PHTS total flow rate of the scaled model was obtained around 550 *lpm* at motor rotation 50Hz, which covers the full flow range of the natural circulation test for the Richardson number matching condition. The measuring data was located within ±10% uncertainty.

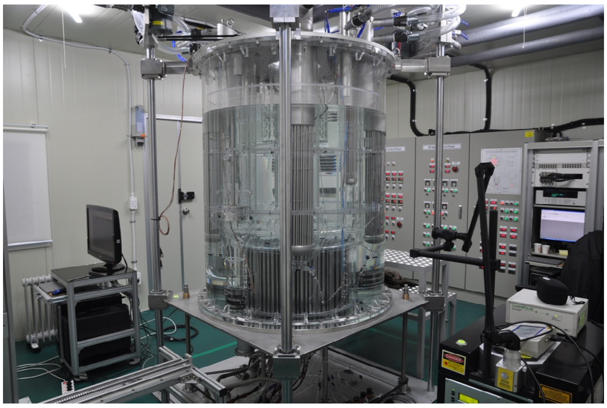

Figure 1. Photo of RV test section

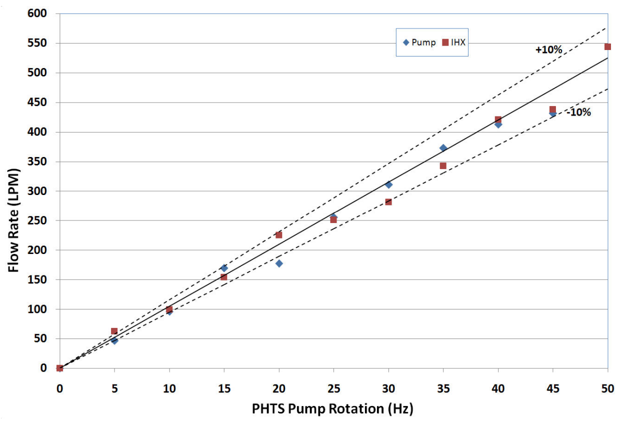

Figure 2. PHTS Flow rate measured by PIV method

Table 1. Time distance of laser pulse for the PIV image capture(μs)

Rotation(Hz)	Pump Inlet	Pump Upper	IHX Exit
5	10,000	10,000	3,000
10	8,000	8,000	2,000
20	5,000	3,000	1,000
30	3,000	1,500	600
40	1,500	800	500
45	1,000	700	500
50	800	600	500

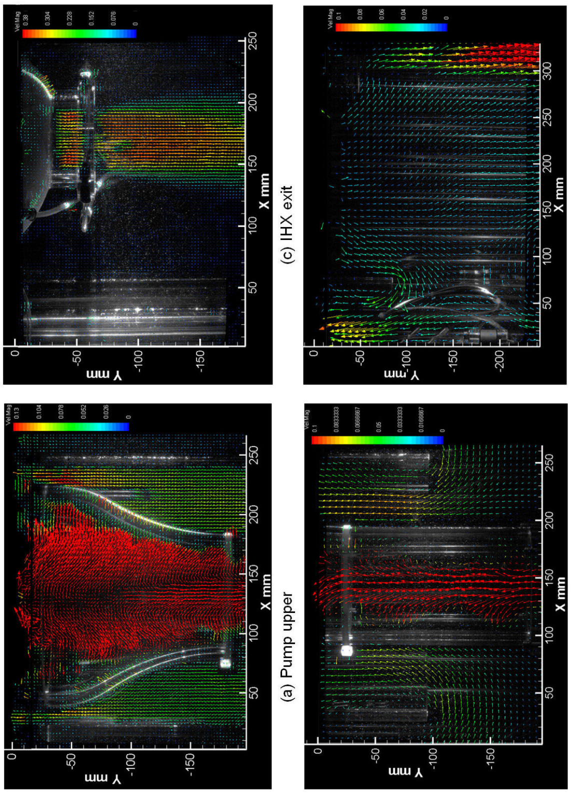

Figure 3. Flow field in the vicinity of Pump and IHX

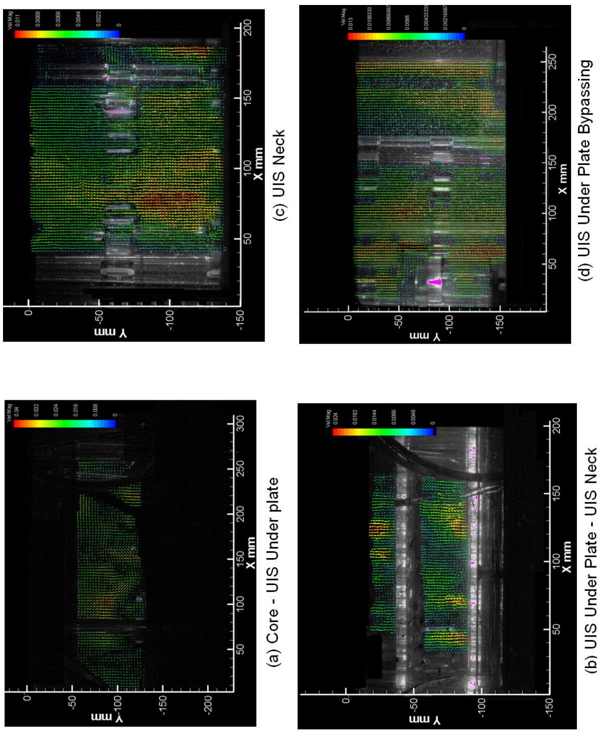

Figure 4. Flow field in the vicinity of UIS

Figure 3~5 show the flow field in the isothermal condition to investigate a global behavior of test facility.

Figure 3 shows the flow distributions in the cold pool in the vicinity of the PHTS pump and IHX exit. Flow recirculation was existed along the pump duct inner surface in the vicinity of the pump inlet region. Highly strong swirl was also seen in the downstream of the pump propeller. The IHX exit flow hits RV bottom wall in case of high motor rotation and part of flow was circulated between the pump inlet and IHX exit. Very complicated flow was shown in this area.

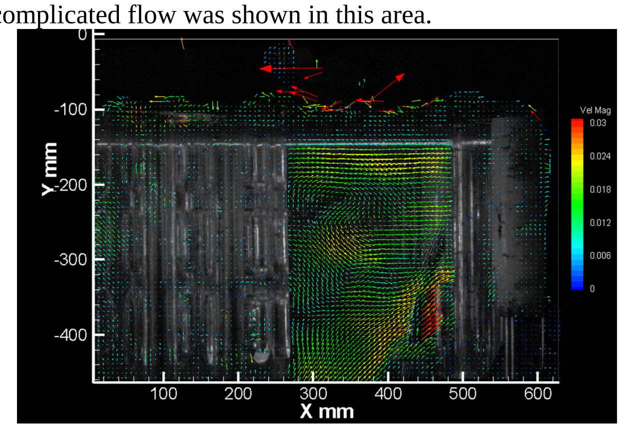

Figure 5. Flow field in the vicinity of UIS and free surfae

Figure 4 shows the flow field between the core exit and UIS upper region. Flow recirculation was existed in the region between core exit and UIS under plate. Flow passing the UIS bottom hole can be smoothly flowing upward. Part of flow was entrained from the hole in the inner region of UIS neck. Figure 5 shows a flow field under free surface and IHX inlet region. Flow nearby the free surface was entered into the IHX inlet after then large circulation and the IHX inlet flow was also not uniform with the circumference direction. From the PIV test, a complex three dimensional flow field was monitored despite of cold water test.

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 1/10th water scaled reactor model. An isothermal global flow field was measured with PIV method as well as PHTS flow rate of the scaled water model.

ACKNOWLEDGMENTS

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REFERENCES

[1] J.E. Cha, S.H. Lim, H.W. Kim, S.O. Kim and Y. I. Kim, Scoping Test of a Water Scaled Model for the Thermal Hydraulic Study of 600MWe-SFR, Transactions of the Korean Nuclear Society Spring Meeting, Taebaek, Korea, May 26-27, 2011