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Preliminary descriptions on the 6 x 6 reflood test of KAERI - Part I: Overview of the test facility and matrix

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1. Introduction

The 6x6 reflood test facility has been constructed by KAERI to quantify rewetting mechanism and evaluate the effect of dispersed flow cooling with respect to droplet behavior. The test section consists of a simulated 6 x 6 rod bundle, a flow housing, 4 pairs of borosilicate glasses for a visual observation and instrumentation. Axial power shape of the simulated heater rod is cosine. Peaking factor and heated length of the rod bundle are 1.468 and 3,810 mm, respectively. Special features of this facility are a separator tank to measure the amount of entrained droplet and a superheated steam probe for the measurement of superheated steam temperature in sub-channel. The experimental results from this study will be useful for the performance evaluation and the program update of the related computer code.

2. Descriptions on the test facility

2.1 Objectives

KAERI has constructed the test facility for the simulation of reflood phase. The objectives of the present study can be summarized in the following three items.

(1) Enhancement of the understanding on thermal hydraulic behavior in the reactor core during the reflood phase.

(2) Evaluation of the rewetting mechanism including the rewetting temperature behavior and rewetting velocity variation with respect to the experimental parameters.

(3) Investigation on the effect of the spacer grid during the reflood period by quantifying the droplet behavior at the upstream and downstream sections of spacer grids.

In this paper the current statue of the 6x6 reflood facility and test matrix will be described

2.2 6x6 reflood test loop

KAERI has finished its construction and now on the way of preliminary test sequence. The main test will be launched in this October. The 6x6 facility consists of a test section, separating system for measuring the amount of entrained liquid droplet, pressure oscillation damping system to control the system pressure during preparation and testing period, coolant supply system and steam supply system. The schematic diagram of 6x6 facility can be seen in Fig. 1. In the coolant supply system 50 kW preheater was installed to control the temperature of coolant. The function of the steam supply and pressure oscillation damping system is to increase and control the system pressure and temperature at the specified pressure level. The system pressure will be accurately controlled by CV-02 and CV-03. The coolant flow rate can be measured by orifice flow meter installed at the downstream of injection pump. The instruments to measure the temperature and pressure were installed at suitable location of the loop to evaluate the operating condition and thermal hydraulic properties.

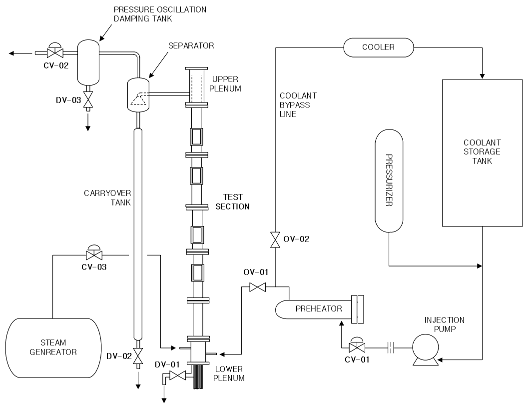

Fig. 1 Schematic diagram of 6x6 reflood test facility

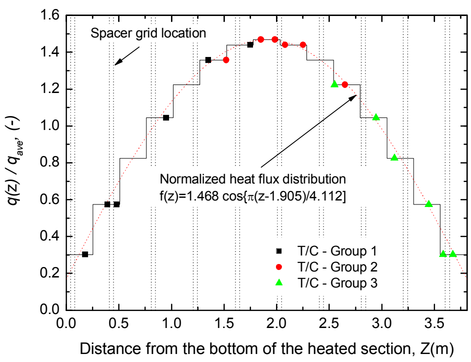

Fig. 2 Axial power shape of 6x6 rod bundle

2.3 Test section

A 6x6 rod bundle, of which the length of heated

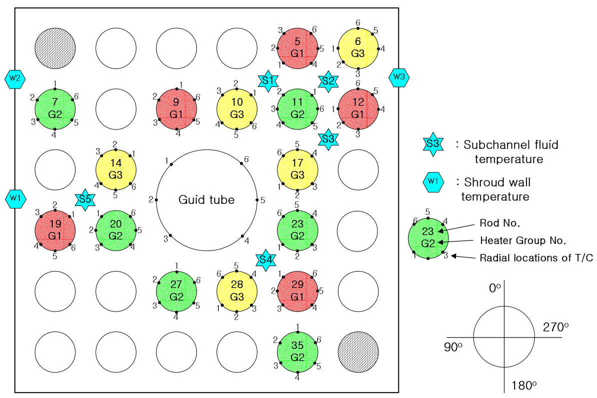

Fig. 3 Schematics of heater rod configuration and location of thermocouple probes embedded at the cladding of instrument heater rods

section and the power shape along the axial direction are 3.81 m and cosine respectively, as depicted in Fig. 2, consists of 30 heated rods, 2 unheated rods, a guide tube in the center of the bundle and connection flange. The heater rods, of which the outside diameter (D) is 9.5 mm, are indirectly heated by the electric power of 3 phases, 440 VAC at which the maximum power of each rod is 10 kW. The pitch (P) to diameter ratio is 1.35. Along the axial length of the rod bundle total 11 spacer grids with swirl vane had been assembled and the mean interval of neighboring spacer grids is 400 mm. Technical specifications of the rod bundle is shown in Table 1.

To measure the thermal behavior of cladding during the reflood period total 102 T/C probes were embedded on the cladding of 16 instrument rods and a guide tube along the axial and radial direction as shown in Figs. 3 and 4. To measure the cladding temperature at various axial locations the heated rods were divided into three groups according to the axial locations of T/C probes, of which the distribution can be seen in Figs. 3 and 4. Fluid temperatures in the subchannels can be measured at 16 points along the axial height.

The 6x6 rod bundle is enveloped by 5 pieces of outer shrouds and inlet and outlet plenum connected to the coolant supply and separating system respectively. At the 4 pieces of the outer shrouds 4 pairs of borosilicate glasses were installed for the visual

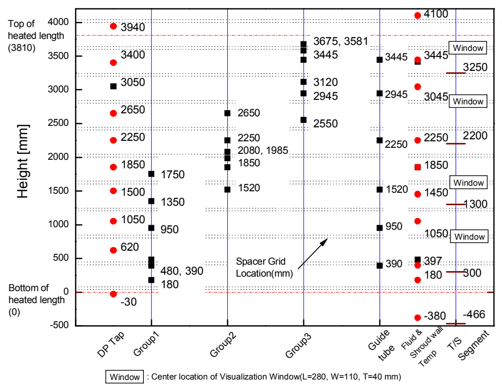

Fig. 4 Instruments location along the test section and visualization windows

Table 1 Technical specifications of 6x6 rod bundle

Parameter	Symbol	Unit	Value
Type of spacer grid	-	-	swirl-vane
Sheath material	-	-	Inconel 600
Sheath diameter	D_{sh}	mm	9.5
Pitch to diameter ratio	*P/D*	-	1.35
Heated length	*L*	mm	3,810
Axial power shape	-	-	Cosine, (PF: 1.468)
Number of Heated/Unheated rods	-	EA/EA	30/2

observation of droplet and entrainment and rewetting behavior. The relative location of visualization window and pressure taps with the heated length of rod also can be seen in Fig. 4.

2.4 Special features

The degree of superheating of steam in the upper part of the subchannel is very important to evaluate the heat transfer capability during reflood. No available data, however, can be found in the open literature due to its inherent difficulty to prevent saturated or subcooled liquid droplets from the contact with the measuring probe. In the present study, the authors attempt to measure the superheating degree of fluid by devising special probe.

Table 2 Test matrix of 6x6 reflood test

Parameter	Symbol	Unit	Value
Flooding velocity	U_F	cm/s	2, 5, 8
Inlet coolant temperature	T_{in}	°C	20, 50, 80
Initial wall temperature	T_w	°C	500, 600, 700
System pressure	*P*	bar	1, 4, 8

3. Test matrix

Table 2 shows the preliminary test matrix derived from the pervious study of the authors [1]. The initial wall temperature measured at 2945 mm from the bottom end of heated length, corresponding to the second lowest T/C of Group 3 instrument rods.

4. Conclusions

To enhance the performance of the reflood model the rewetting phenomena and the droplet behavior have to be accurately quantified. The experimental data of the present study will be useful for the performance evaluation and the program update of the related model.

References

[1] S. Cho, S.-Y. Chun, W.-P. Baek, M.-K. Chung, 2005, "Spacer grid effect during reflood in an annulus flow channel," NURETH 11, Avignon, France, to be published.