Experimental Investigation of Natural Circulation in Regional Energy Reactor-10MW$_{th}$

Byeong-Ill Jang[a*], Gyoo-Dong Jeun[a], Moo-Hwan Kim[b]
[a] *Department of Nuclear Engineering, Hanyang University, 17,Haengdang-dong, Seongdong-Gu, Seoul, 133-791, Republic of Korea*
[b] *Mechanical Engineering Department, POSTECH, Pohang, 790-784, Republic of Korea*
[*] *Corresponding author:gksdideobi@hanyang.ac.kr*

1. Introduction

A small- and medium-sized nuclear reactor (SMR) has drawn attention because it is used for multi-purpose applications of desaltination, district heating, ship propulsion and small-scale power generation. The SMR has the virtue of providing for the safety more than a large-sized nuclear reactor. It can be avoidable the occurrence of a large break LOCA because the primary pipes are eliminated. And as the SMR is designed to simplify the geometries and safety systems, uncertainties about the reactor operations are reduced and its safety improves. RERI (Regional Energy Research Institute for Next Generation) is designing REX-10 (Regional Energy Reactor 10 MW$_{th}$) based on SMART-P. This reactor must improve the enhanced safety because the main purposes of it are small-scale power generation and district heating. From this reason, REX-10 adopts the way to remove heat by natural circulation. And to investigate the natural circulation characteristics of REX-10, we constructed RTF (REX-10 Test Facility) in RERI. The main aim of this article is to evaluate the natural circulation behavior under various experimental conditions.

2. Experimental Facility

The REX-10 Test Facility (RTF) is designed to study the characteristics of natural circulation in REX-10. The experimental facility is scaled down using the scaling law proposed by Ishii and Kataoka(1984)[2] and its schematic diagram is shown in **Fig.1**.

A primary loop of the experimental facility is composed of a core, hot legs, a heat exchanger and a pressurizer. The core consists of 60 electric heaters that generate 200kW. Their diameter and length is 12 mm and 1 m, respectively. Hot legs are designed to measure a primary flow rate. The type of the heat exchanger is once-through helical coil heat exchanger, which consists of 12 helical coils. A helical coil is 3/8 inch in diameter and about 4.38 m in length. The pressurizer is located in the highest part of the RTF and installed to control the primary pressure. All parts of the primary side of RTF are insulated to minimize heat loss due to the surface. A secondary loop consists of helical coils and chillers. Chillers provide the feedwater to the RTF at the required temperature and the volume flow rates.

In this experiment, 32 K-type thermocouples, 4 turbine flow meters and 2 pressure gauges are used to obtain the temperature, flow rate and pressure data. All measuring points are shown in **Fig.1**. All data are collected by the Data Acquisition System (DAS).

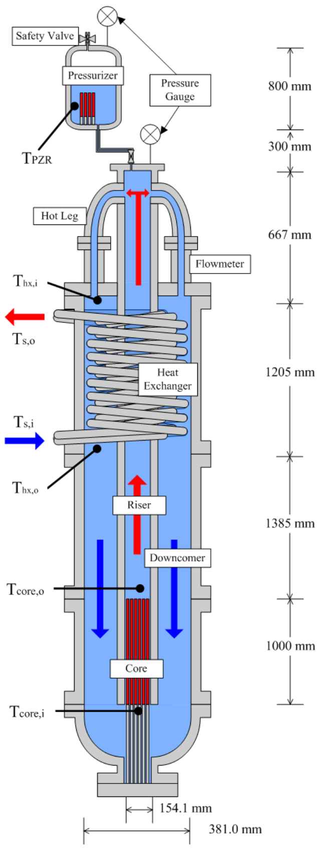


Fig. 1 Schematic diagram of the experimental facility

3. Experiments

To evaluate the natural circulation characteristics of the RTF, we choose two parameters – the electric heater powers and the secondary flow rate. To examine the effect of the heater power, the experiments were carried out at various electric heater powers keeping other parameters (the secondary flow rate and the primary pressure). And to evaluate the effect of the secondary flow rate, the experiment conducted in the similar manner. The test matrix is summarized in **Table I**.

Table I Test matrix

Test		Power (kW)	Secondary flow rate (LPM)	Pressure (bar)
Effect of the Heater Powers	RTF-VHP-25-10	Various	2.5	10.0
	RTF-VHP-35-20	Various	3.5	20.0
Effect of the Secondary flow rate	RTF-100-VSF-10	100	Various	10.0

4. Results and Discussions

4.1 Effect of the Heater Powers

We have conducted the experiments at varying heater powers under constant primary pressure and secondary flow rate in order to examine the effect of the heater powers. These experimental cases are shown in **Table I**. VHP means the various heater powers. These experimental results are below. The temperature difference and the flow rate of natural circulation increases with increasing input power.

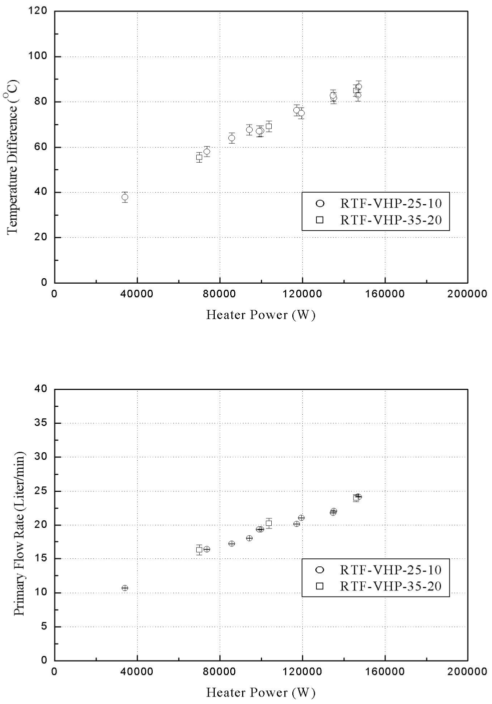
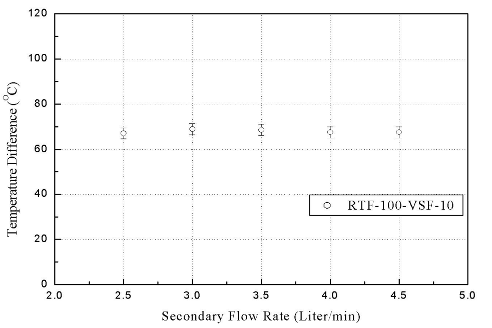


Fig. 2 Effect of the Heater Powers

4.2 Effect of the Secondary Flow Rate

To find out the heat transfer characteristics of helical coils, we have carried out the experiments at various secondary flow rates. This experimental condition is shown in **Table I**. VSF means the various secondary flow rates. The temperature difference and the primary flow rate hardly change as shown **Fig.3**.



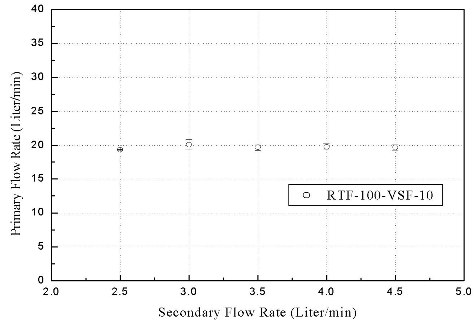


Fig. 3 Effect of the Secondary Flow Rates

5. Conclusions

To study the natural circulation characteristics of the RTF, we had experiments with two parameters – the heater powers and the secondary flow rate. The most important parameter that affects the flow rate of natural circulation is the heater powers. But the secondary flow rate doesn't change at varying secondary flow rates. In near future, we will conduct the experiments in the case of the varying primary pressures and simulate the experimental results using the MARS code.

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