Resonance Control Cooling System for RAON RFQ

Bum-Sik Park* and In-Seok Hong
Rare Isotope Scienc Project, Institute for Basic Science,
1, Gukjegwahak-ro, Yuseong-gu, Daejeon, Korea
**Corresponding author: bspark@ibs.re.kr*

1. Introduction

The Rare isotope Accelerator complex for ON-line experiments (RAON) is constructing a heavy ion accelerator facility to produce new rare isotopes and provide various research opportunities [1]. As the front accelerator, a radio frequency quadrupole (RFQ) has been developed and is in the beam commission stage [2-3].

In general, there are two methods to control the resonance of the RFQ cavity. One is the frequency tuning method by a local movable tuner, which is no longer adopted in an RFQ operation, and the other is temperature control by a resonance control cooling system (RCCS). There are several ways to tune the resonant frequency using cooling water for the 4-vane RFQ, depending on whether walls or vanes are controlled individually or simultaneously. Moreover, there are two ways to control the coolant: temperature mode and phase mode [4].

RAON RFQ was installed 10m underground and connected to RCCS by pipes of about 20m. Additionally, the total weight of the RFQ cavity is approximately 12 tons. Therefore, it is very difficult to quickly control the RFQ frequency by adjusting the cooling water temperature. In this paper, the result of test operation in constant temperature mode with the RAON RCCS system was introduced.

2. Cooling System

2.1 RCCS Cooling System

Fig. 1 shows the flow diagram of the water-cooling skid for the RAON RFQ. It consists of two loops and heat transfer occurs through the heat exchanger. One is connected to the cavity to form an internal closed loop, and the other is supplied with approximately 10℃ of chilled water from the conventional facilities. The temperature of the cooling water in the inner closed loop is controlled by measuring the temperature of the outlet coolant just behind the RFQ cavity. Moreover, the temperature of the cooling water which supplied to the cavity is controlled by adjusting the mixing rate of chilled water through a 3-way valve. The capacity of the inner loop tank is about 1 ton. For no-load operation and initial operation of the cooling system, an immersed electric heater with a capacity of 30 kW was applied to raise the cavity temperature to 33.5℃, which is the initial operating temperature.

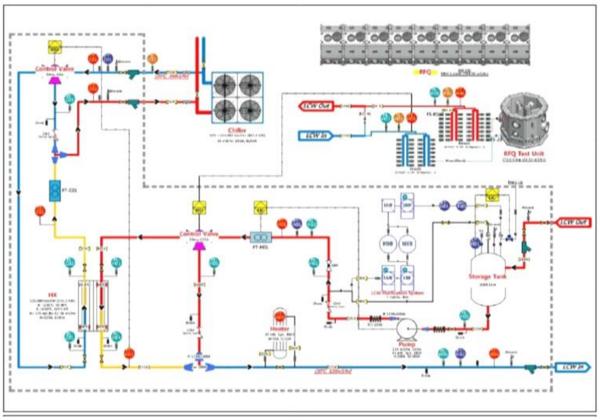

Fig. 1. Flow diagram of the RAON RCCS.

2.2 RFQ Cavity Cooling System

The RAON RFQ consists of a total of nine sections, each of which consists of four vanes and four quadrants, as shown in Fig. 2. Each vane has two cooling channels. One is located near the beam axis and has a diameter of 12 mm. And a second cooling channel is placed below the vane base. In addition, cooling channels are built into quadrants, tuners, power couplers, endplates and undercuts. Fig. 3 shows the flow diagram for each cooling channel. The flow meter, thermometer and the valve were installed for each cooling channel so that the flow rate of each channel could be controlled. Fig. 4 shows the layout of the pipe connections.

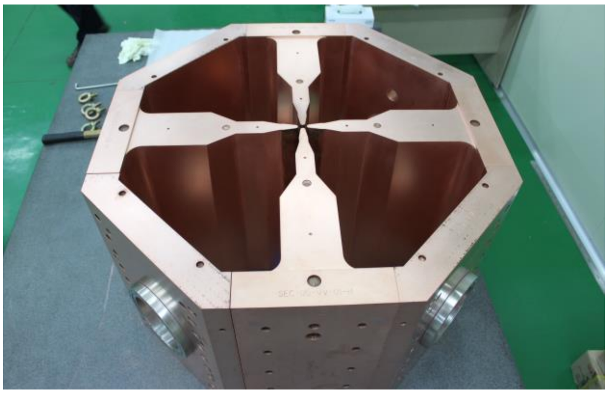

Fig. 2. RFQ cross-section of one of the nine sections. Holes for cooling channels in vanes and quadrants were plugged.

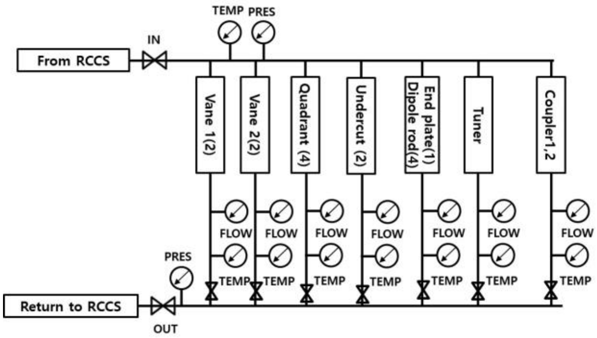

Fig. 3. Water-cooling system model of the RFQ cavity.

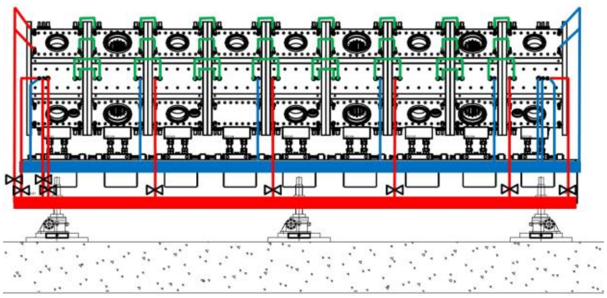

Fig. 4. Pipe connection of the RFQ cavity.

3. Resonance Control

The RCCS controls the cooling water temperature using the EUROTHERM 3500 controller with the PID algorithm. The RAON RCCS is required to control the cooling water temperature within ±0.1℃. In the initial state, the heater is turned on and the cavity is heated to 33.5℃. Then the PID algorithm is activated to control the cooling water temperature to 33.5±0.1℃.

During the pulsed beam commissioning experiment, the RFQ was operated in temperature control mode. As shown in Fig. 5, the temperature of chilled water supplied from the convention facility changes periodically. However, the cooling water supplied to the RFQ cavity is successfully controlled at 33.5±0.1℃.

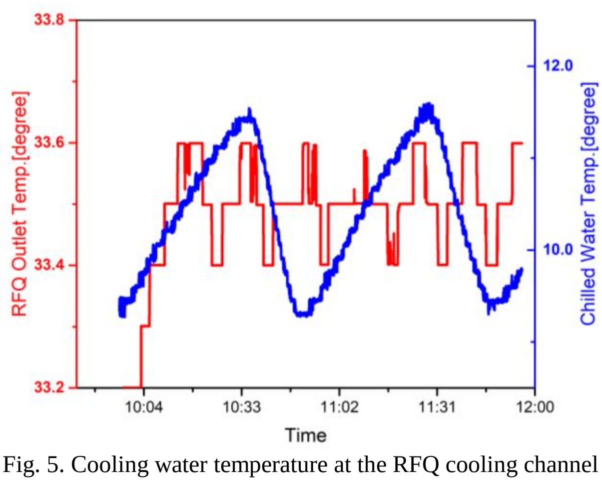

Fig. 5. Cooling water temperature at the RFQ cooling channel outlet and the chilled water temperature supplied by the convention facility

4. Future Plan

An RCCS for RAON RFQ has been developed. And it is under beam commissioning. However, the large size of the RFQ cavity as well as the long pipe between RFQ and RCCS limits the application of frequency control mode. Nevertheless, a study will be conducted on frequency sensitivity according to the coolant flow rate. Through this, the application of the frequency control mode will be considered.

Acknowledgment

This work was supported by the Rare Isotope Science Project of Institute for Basic Science funded by Ministry of Science and ICT and NRF of Korea (2013M7A1A1075764)

REFERENCES

[1] S. K. Kim, et al., Baseline Design Summary, https://www.risp.re.kr/orginfo/info_blds.do.
[2] B.S. Park, et al., Nucl. Instrum. Methods Phys. Res., 463, pp. 345-347, 2020.
[3] B.S. Park, et al., J. Korean Phys. Soc. 73, p.1111-1114, 2018.
[4] X. Wenqu, O. Huafu, and X. Taoguang "Resonance control cooling system for 973 RFQ at IHEP." Nuclear Physics Review Vol.30, No.2, p. 136, 2013.