RESONANCE FREQUENCY CONTROL CHARACTERISTICS OF THE 100-MEV DRIFT TUBE LINAC*

Hyeok-Jung Kwon#, Yong-Sub Cho, Ji-Ho Jang, Han-Sung Kim, Kyung-Tae Seol, Young-Gi Song, KOMAC/KAERI, Gyeongju, Korea

Abstract

A 100-MeV, 20mA proton accelerator has been developed by KAERI (Korea Atomic Energy Research Institute). Total 11 sets of DTL (Drift Tube Linac) tank are used to accelerate the proton beam from 3-MeV to 100-MeV. A RCCS (Resonance Frequency Control Cooling System) has been developed to control the resonance frequency of each DTL tank. The coolant for the drift tube and quadrupole magnets is supplied by the RCCS, whereas the wall coolant temperature maintains at 27°C by the cooling skid. In this paper, the resonance frequency control schemes are summarized and the control characteristics of the DTL tank by using RCCS are discussed.

INTRODUCTION

A 100-MeV proton linac has been developed by PEFP (Proton Engineering Frontier Project), which is the first phase of KOMAC (Korea Multipurpose Accelerator Complex). [1][2]

The 100-MeV accelerator consists of 50-keV proton injector, 3-MeV RFQ (Radio Frequency Quadrupole) and 100-MeV DTL. The resonance frequency of each DTL tank is controlled by using the RCCSs. To separate the cooling loop for copper and steel, the RCCS supplies cooling water to drift tube and electromagnet. The coolant for DTL tank wall is supplied by a separate cooling skid. The cooling skid for the wall is designed for constant water temperature whereas the RCCS is designed to track the resonance frequency errors.

Total 11 RCCSs are used to control the resonance frequency of each DTL tank and total 3 cooling skids are used, one for RFQ, another for 20-MeV DTL, and the third for 100-MeV DTL. One chilling system supplies 10°C coolants to both 11ea. RCCSs and 3ea. cooling skids. All systems are installed and the commissioning is now progressed. In this paper, we focus on the RCCS.

RESONANCE FREQUENCE CONTROL COOLING SYSTEM

Installation and Initial Test

The specifications of the RCCS are summarized in Table 1. As shown in the Table, the RCCS should cover the temperature from 21°C to 33°C, heat load from magnet power only to full RF power in addition to the magnet power. The stability of the temperature control is less than 0.1°C. The control input variable comes from the resonance frequency error from the low level RF (LLRF) system. The schematic of the RCCS is shown in Figure 1. As shown in the Figure 1, two 3-way valves are used to cover both the wide operating temperature range and heat load range.

Table 1: RCCS specification

Parameters	Values
Operating temperature	21°C ~33°C
Temperature stability	0.1°C
Chiller temperature	10°C ±0.2°C
Heat load (RCCS21 case)	Only magnet (75kW) ~ Full RF + magnet (95kW)
Valve	3-way mixing valve
Control	EPICS
Resistivity	> 1MΩ cm

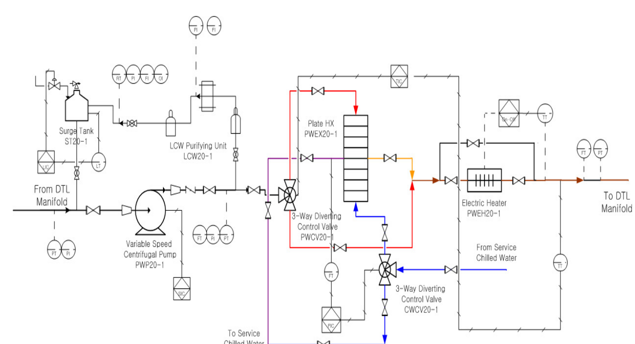

Figure 1: RCCS Schematics.

Each DTL tanks requires independent RCCS for its resonance frequency control. The RCCSs were installed at 2nd floor of the accelerator building whereas the DTL were installed at 1st floor. The RCCS consists of variable speed pump, heat exchanger, 20kW heater to supply the heat load at low duty operation of the DTL, two sets of 3-way valve to control the cooling water temperature and demineralized water (DI) system which is planned to treat 1% flow rate of the RCCS. All components were installed on the skid plate, size of which is 2m (W) × 2.2m (D) × 2m (H). The installed RCCS is shown in Figure 2. The utility interfaces of the RCCS are DI water supply to the primary side, nitrogen gas supply system to the surge tank, and chilled water at secondary side.

* *This work was supported by Ministry of Science, ICT & future Planning of the Korean government
#hjkwon@kaeri.re.kr

Figure 2: Installed RCCS.

The standalone test of the RCCS was carried out before the connection to the DTL to check its control characteristics by using newly built utility system. One chilled water system supplies 10°C water to all the RCCS and 3 sets of constant temperature cooling skid. First, the chiller was tested in conjunction with the RCCS and cooling skid. During the test, all the heaters of the RCCS and cooling skid were operated because the chiller needs heat load for proper operation. The total heat load by using the internal heater was 350kW. In such conditions, the chilled water temperature at the outlet side of the chiller fluctuated from 8°C to 12°C with 4.5 minutes period whereas the temperature at the inlet side of the RCCS fluctuated from 11°C to 12°C with the same period as shown in Figure 3. The chilled water temperature was controlled by only the internal PID control algorithm which was not tuned optimally yet. The RCCS temperatures with 50% openings of each 3-way valve are shown in Figure 4. The fluctuation period was the same to the chilled water temperature and the temperature deviation was ±0.25 °C as shown in Figure 4. Second, the 3-way valve controller was tuned to estimate the proper PID control values. It used the relay method by using the internally programmed algorithm. After the controller tuning, the system could be operated with a temperature deviation less than ± 0.1°C with only primary control valve or both control valve at primary and secondary side. The results are shown in Figure 5 with various operation conditions.

The RCCSs were connected to each DTL tank after standalone test. At the beginning, the RCCS is operating at constant temperature mode with the condition that all electromagnets are operating and the wall temperature is controlled by the 27 °C constant temperatures by cooling skid. The temperatures of each RCCS are maintained with ±0.1°C with respect to the set temperature. The RF characteristics of the DTL tank follow the RCCS temperature variation. For example, the phase of the DTL tank oscillates with the same period to the chilling system temperature variation. Now the phase variation can be controlled by the LLRF system, the temperature control of the chilling system should be revised which affect not only to the RCCS operation but also to the cooling skid operation.

During the test, some problems with respect to RCCS itself were found, and many of them were solve. Two main problems remained are the pressure instability during DI water supply from the storage tank, the other is the interlock caused by the noise. DI water supply to the RCCS system from utility is done by solenoid valve which get signal from the water level at the surge tank. But the system pressure at suction side increases during water supply from the utility due to the pressure of the utility pump, which increases the supply water pressure to the drift tube. The noise trips the RCCS several times during standalone test. The noise source is not confirmed yet, but the noise gave a perturbation to the pressure and flow signals to trip level. Digital filter scheme is installed to decrease this kind of noise effect.

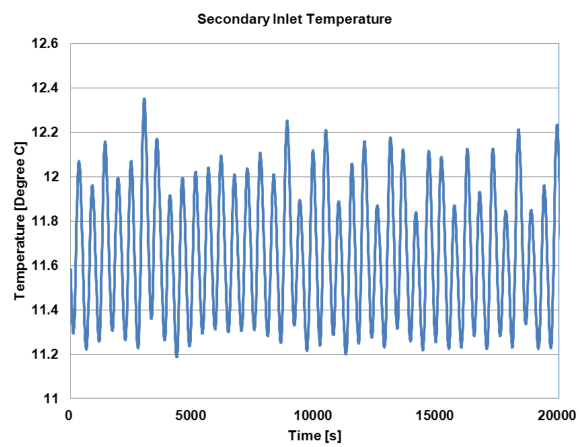

Figure 3: RCCS secondary side inlet temperature.

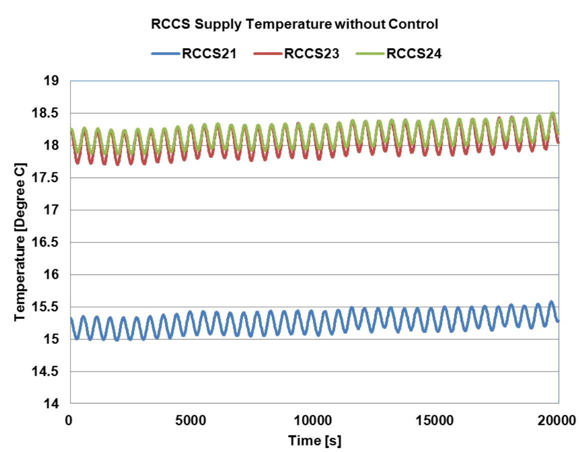

Figure 4: RCCS supply temperature without control (50% opening of both 3-way valve).

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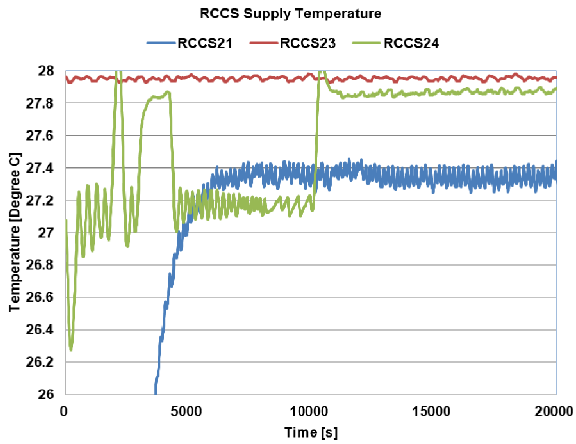

Figure 5: RCCS supply temperature after PID tuning at various operating temperature.

SUMMARY AND FUTURE WORKS

The standalone tests of all RCCS were finished and now RCCSs are used to operate the DTL. During the test, the control characteristics of the RCCS were defined and most of the problems related to the RCCS itself were solved except the pressure instability and noise related interlock. To operate the system properly, not only RCCS itself but other related utility system should be revised.

Up to now, the RCCSs are operating in constant temperature mode, which are not connected to the LLRF frequency error loop. We are going to connect this loop after the characterization of the RCCS itself is finished.

REFERENCES

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