The Resonance Control Cooling System Control Valve Improvement at The KOMAC

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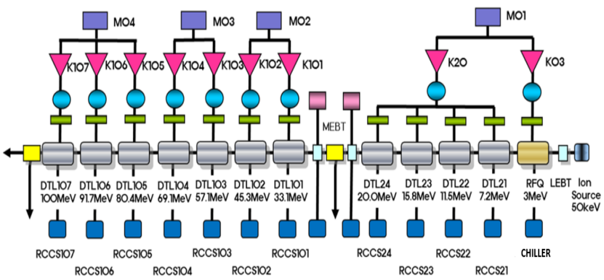
1. Introduction

In Korea Multi-purpose Accelerator Complex (KOMAC) 11 sets of Resonance Control Cooling System (RCCS) are operated to control the resonance frequency of 11 Drift Tube Linac (DTL) tanks. Because the DTL tanks are different from each other, the system was designed such that one RCCS controlled one DTL tank [1]. The RCCS uses 2 number of 3 way control valves for keep the cooling water temperature. One control valve is equipped in the hot side circuit and the other valves is located in the cold side circuit. The hot side circuit and the cold side circuit is indirectly connected by the heat exchanger. Similar function was reported in the other facilities, such as SNS in USA [2]. These 2 control valves in each RCCS has the critical role for sustaining the designated cooling water temperature. This paper describes a RCCS performance improvement by using these control valves.

2. Methods and Results

2.1 System Setup

The resonant frequencies of all the DTL tanks are controlled by independent RCCS. 11 sets of RCCSs laydown is indicated in Figure 1 [3].



M: Modulator
K: Klystron
RFQ: Radio Frequency Quadrupole
LEBT: Low Energy Beam Transport
MEBT: Medium Energy Beam Transport
DTL: Drift Tube Linac
RCCS: Resonance Control Cooling System

Fig. 1. KOMAC Linac Layout [3]

The RCCS is consisted with pump, heat exchanger, 3way valves and accessories. RCCS's piping and instrument diagram is shown in Figure 2.

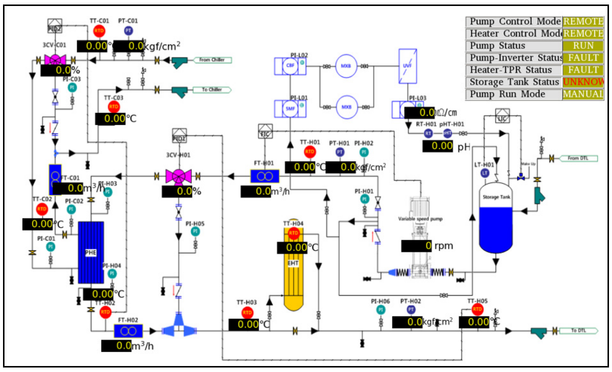


Fig. 2. RCCS's piping and instrument diagram

The cooling water in RCCS is a closed-loop system and cooling water temperature is controlled by adjusting the distribution of flow between the heat exchanger and the heat exchanger bypass line [4]. The hot side 3 way control valve diverts cooling water to remove the heat load on heat exchanger which is connected to cold side circuit. The cold side 3 way valve position is fixed around 60%~80% for removing the temperature fluctuation factor. The RCCS design parameters was shown in Table I [5].

Table I: Design parameters of the RCCS [5]

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

2.2 Operational Experience

The RCCS operational parameters are summarized in Table II. The operation temperatures are determined by measuring dependence of the resonant frequency of each DTL tank [1].

Table II: RCCS operation parameters (20th Aug 2018)

RCCS No.	Operating Temp (℃)	Pressure (kgf/cm2)	Flow rate(m3/h)
21	29.4	2.17	25.04
22	29.1	2.67	26.62
23	33.4	3.39	21.57
24	22.8	2.65	29.8
101	43.5	2.46	27.3
102	30.6	3.21	28.37
103	23.9	3.32	26.37
104	39.9	2.58	20.15
105	25.7	2.1	21.01
106	18.6	2.49	21.03
107	19.9	2.89	21.64

During the operation we noted that hot side 3 way control valve is fail to sustain the set water temperature when the heat load is suddenly increased or chilled water temperature is dramatically changed. The RCCS 101, RCCS 104 were lost the temperature control according to Figure 3.

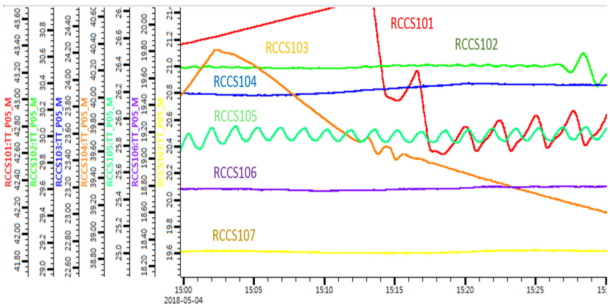


Fig. 3 RCCS cooling water temperature (Hot side 3way control valve control case)

This failure has the critically negative impact on the beam stabilization by causing radio frequency fluctuation with the high resonance error.

In addition the hot side circuit is directly connected to DTL. So the hot side 3 way control valve's actuator movement makes the water supply pressure fluctuated consistently even the actuator's small movement. Refer to the Figure 4, the water temperature is stable but the hot side 3 way control valve movement changes the water supply pressure which reach to increase the resonance error range around -2.8 ~ +1.4.

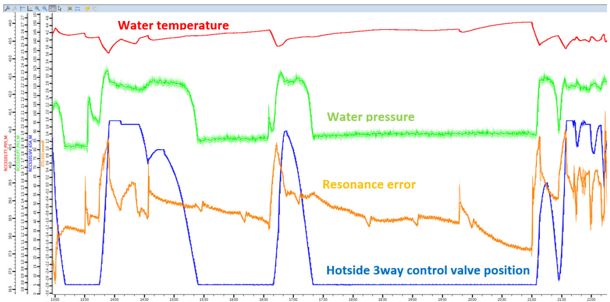


Fig. 4 RCCS 101 performance (Cold side 3way control valve control case)

2.3 Improvement

The RCCSs were designed to operate with minimized cooling water temperature fluctuation within ±0.1℃. Under the stable conditions this would equate to approximately ± 2 kHz resonance error in the DTL. For the operation the resonance error shall be within ± 5 kHz [6]. The cold side 3way control valve can solve above mentioned issue. The main reasons are that cold side 3way valve has no direct connection to DTL and has the large capacity to cover heat load comparing the hot side 3way control valve due to chilled water's low temperature. Figure 5, 6 can help to explain the relation among the RCCS's hot side circuit, RCCS's cold side circuit and DTL.

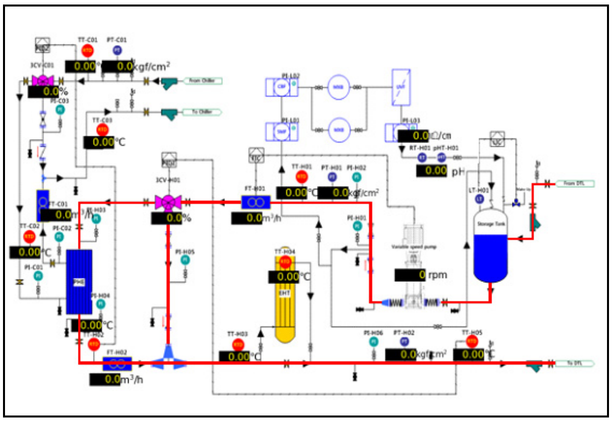


Fig. 5 RCCS hot side circuit control PID

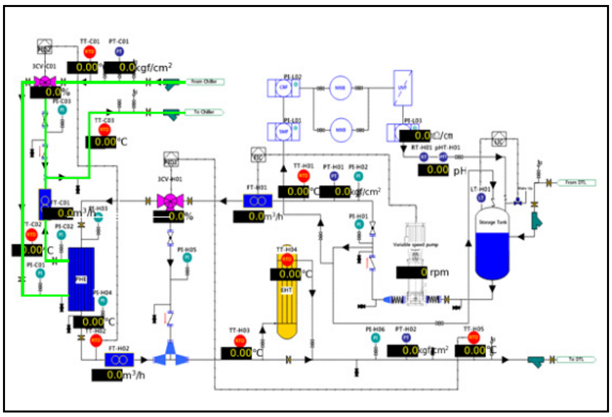


Fig. 6 RCCS cold side circuit control PID

As per above mentioned reason the control mode was changed from the hot side 3way control valve to the cold side 3way control valve with the suitable PID tuning.

2.4 Result

By using the cold side 3way control valve the temperature control was greatly improved. Figure 7 shows each RCCS cooling water temperatures are stabilized within ±0.1℃.

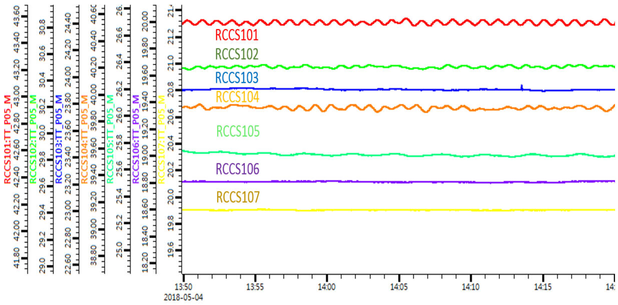


Fig. 7 RCCS cooling water temperature (Cold side 3way control valve control case)

Focusing on the RCCS 101 performance, the water pressure consistency is remarkably improved which contribute to reduce the resonance error. The resonance error range was decreased to -0.4 ~ +0.5 successfully.

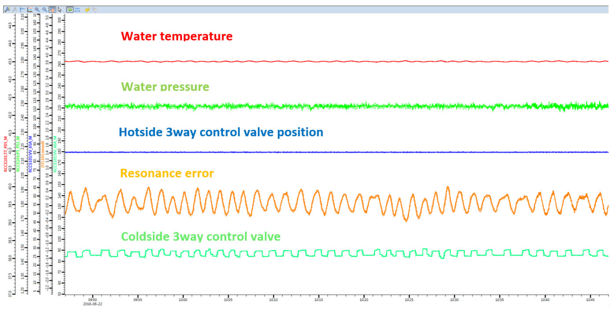


Fig. 8 RCCS 101 performance (Cold side 3way control valve control case)

3. Conclusions

To minimize the resonance error is a critical factor in DTL to operate the 100-MeV linac at the KOMAC. The 11 sets of RCCS can give the heavy contribution to reduce the resonance error by improving control method with constant water temperature and supply water pressure.

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