Interlock Implementation of Resonance Frequency Control Mode for Resonance Control Cooling System at KOMAC

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1. Introduction

The Korea Multi-purpose Accelerator Complex (KOMAC) has 11 sets of Drift Tube Linac (DTL) tank in order to accelerate the proton beam from 3-MeV to 100-MeV [1]. 11 sets of The Resonance Control Cooling Systems (RCCS) are in the operation to control each DTL tanks due to the each DTL's different characteristics [2]. RCCSs have a critical role in cooling the drift tube and controlling resonance frequency of the drift tube by changing cooling water temperature.

2. Methods and Results

2.1 System Setup

The RCCS is consisted with pump, heat exchanger, 3way valves and accessories on the skid plate, size of 2m(W) x 2.2m(D) x 2m (H) as per Figure1[2].

Fig. 1. RCCS's piping and instrument diagram.

The piping and instrument diagram is indicated in Figure 2 which shows cold side circuit and hot side circuit.

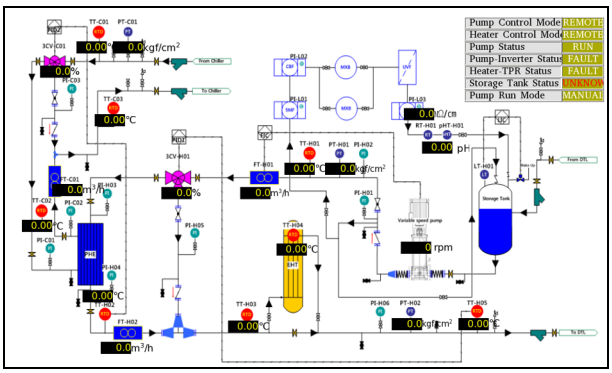

Fig. 2. RCCS's piping and instrument diagram [2]

The RCCS operating parameters are different based on the DTL tanks. It is summarized in below Table I.

Table I: RCCS operation parameters (4th Mar 2024)

RCCS No.	Operating Temp (℃)	Pressure (kgf/cm2)	Flow rate(m3/h)
21	27.8	2.1	28.5
22	39.3	2.1	23.0
23	21.7	2.8	23.7
24	26.1	2.6	21.0
101	47.4	2.4	30.1
102	31.1	2.1	23.5
103	23.8	2.3	23.3
104	39.9	2.3	34.1
105	30.6	3.0	23.1
106	19.5	3.2	22.4
107	22.1	3.0	22.2

2.2 Method

The RCCS can be operated based on two operational modes; one is a constant temperature mode, and the other is a frequency control mode. The constant temperature mode means that the temperature of the water is controlled by using the temperature set value whereas the frequency control mode uses frequency error between the cavity's resonance frequency and the driving frequency as a control variable [3]. Block

diagram of RCCS frequency control mode is shown in Figure 3.

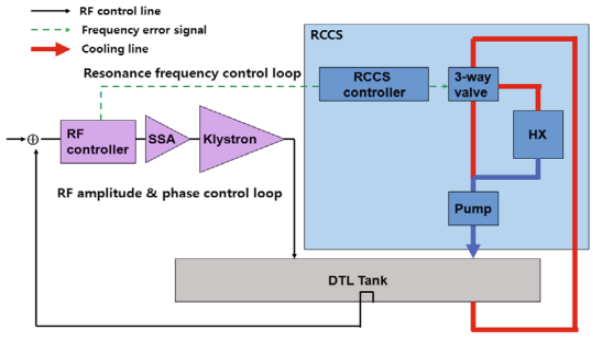

Fig. 3. Block diagram of the RCCS frequency control mode

In the frequency control mode, the frequency error was calculated and transferred to cooling water temperature. RCCS 3way control valve is received the set temperature value and change the valves opening position. The resonance frequency (RF) drops under 4 kHz with every 1℃ of temperature rise [4]. In the frequency control mode, the standard deviations of the resonant frequency errors were withing ±0.065 kHz at KOMAC [5].

RCCS control mode shall be changed from the frequency control mode to the constant temperature mode when the RF is lost due the equipment trouble otherwise RCCS cooling water temperature will be increased or decreased without the limit due to the invalid value.

RCCS's control system is based on AB PLC. The PID control logic was programed for two control modes as below ladder diagram (Figure 4).

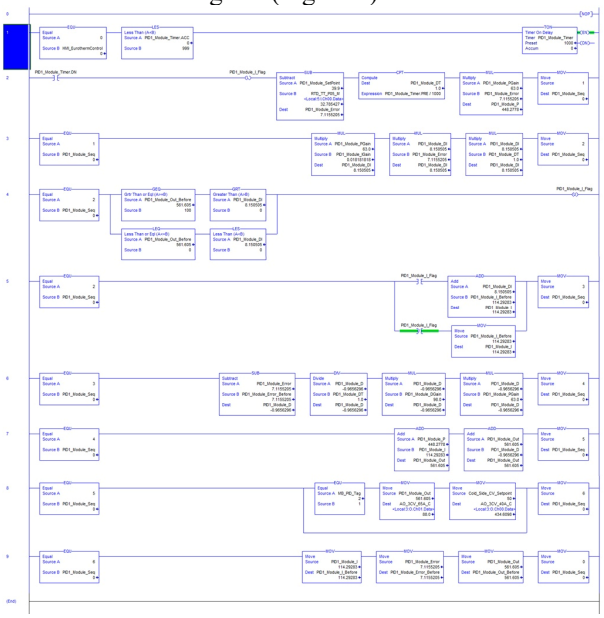

Fig. 4. Ladder diagram for PID control

2.4 Result

The interlock for frequency control mode was implemented. The resonance frequency error value is over or less than the designated values during the frequency control mode as below table II.

Table II: RCCS resonance error operation parameter

	RCCS No.										
Resonance error	21	22	23	24	101	102	103	104	105	106	107
Operation value	-2.48	-2.6	-1.56	-2.43	0	0	0	0	0	0	0
High limit	0	0	0	0	2	2	2	2	2	2	2
Low limit	-5	-5	-5	-5	-2	-2	-2	-2	-2	-2	-2

The designated value was inputted on the control monitor as per Figure 5.

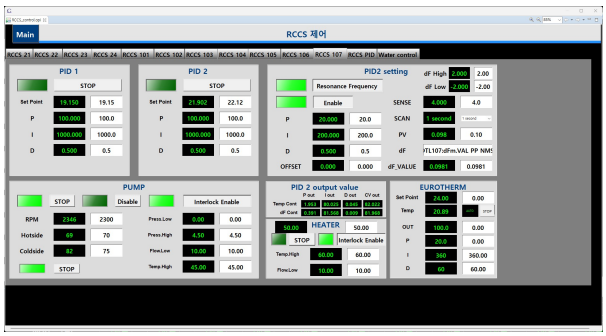

Fig. 5. The control monitor for RCCS 107

In addition, another interlock was adopted preventing increasement of cooling water temperature over the limit during the frequency control mode. The limit high logic was added in RCCS. So below ladder was incorporated into RCCS control module.

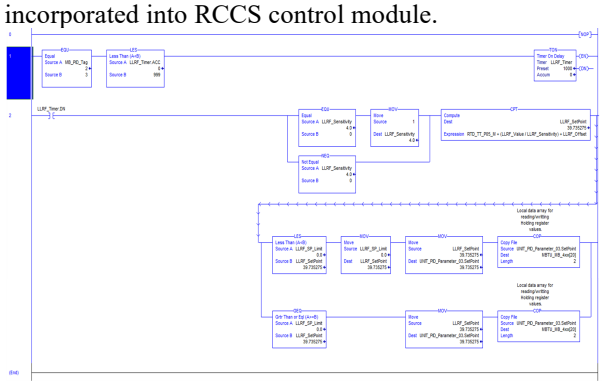

Fig. 6. Ladder diagram for limit high temperature

The resonance error is calculated and converted into the temperature for RCCS's resonance frequency control, but the temperature will not exceed the limit high set value. This interlock is also integrated in the control monitor as below Figure 7.

Fig. 7. The control monitor with limit high

3. Conclusions

Interlock for the resonance frequency control mode was implemented into the RCCS control logic. Adding interlock system for utility equipment closely related to accelerator operation is a critical part for operating accelerator sustainably. As future work, we will investigate the stability of two control modes which have different characteristics.

ACKNOWLEDGMENT

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