Transactions of the Korean Nuclear Society Virtual Spring Meeting
July 9-10, 2020

Implementation of Automatic Water Makeup System for The Resonance Control Cooling System at The 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]. A Resonance Control Cooling Systems (RCCS) are operated to control the resonance frequency of each DTL tanks. A dissolved oxygen concentration and resistivity is managed by side streams built into the cooling loops of the RCCS. According to the 2019 year operation report RCCS trip happened for 1.63 hours per one year due to the interlock with the surge tank low level and water supply pressure low. To accommodate the any leakage into cooling water system and prevent the trip of interlock with the surge tank low level, we implement the automatic water makeup system to RCCS.

2. Methods and Results

2.1 System Setup

The RCCS is a closed-loop system and 3 way mixing valve control the water supply temperature based on temperature control mode and resonance frequency control mode. The RCCS design parameters was indicated in Table I.

Table I: Design parameters of RCCS

Parameters	Values
Operating temperature	18°C ~45°C
Temperature stability	0.1°C
Chiller temperature	11°C ±0.2°C
Heat load (RCCS21 case)	Only magnet (75kW) ~Full RF + magnet (95kW)
Valve	3-way mixing valve
Control	EPICS
Resistivity	> 1MΩ ㎝

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 [2]

RCCS's piping and instrument diagram is shown in Figure 2[3].

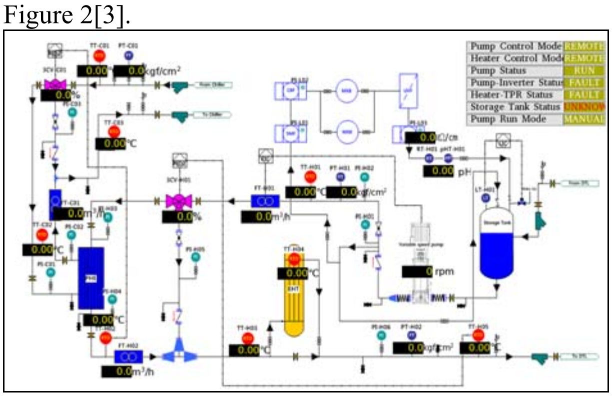

Fig. 2. RCCS's piping and instrument diagram [3]

The water surge tank addresses thermal expansion and contraction. The water makeup in the water surge tank is required because the deoxidization system continuously extracts the gas and wet vapor from the close system. In addition we noted that main reason of trip of RCCS is interlock with surge tank level low and water supply pressure low for 1.63 hour based on the 2019 year operation report. The operation of the deoxidization system requests the regular water make up otherwise RCCS water pressure and flow rate will be lower to the interlock level refer to the Figure 3.

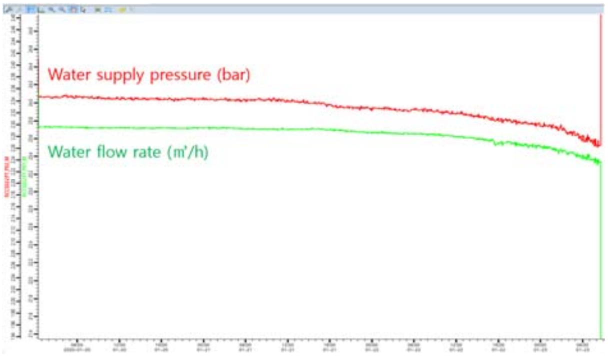

Fig. 3. RCCS22 water supply pressure and flow rate before interlock activation

During the operation we checked the possibility of air pocket and water leakage around the skid. So we found that 3 points of air vent are required on the top of the filter modules. In the manual water makeup mode, this activity has the effect on the water supply pressure which is increased from 2.39 bar to 2.44 bar shown in Figure 4.

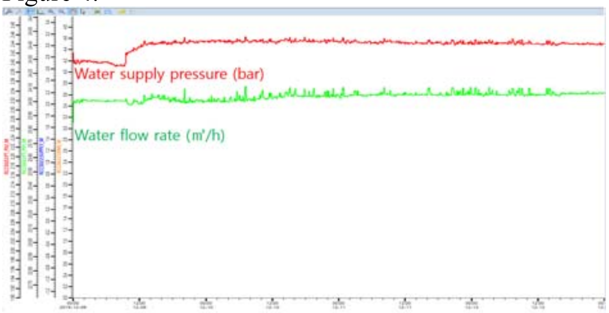

Fig. 4. RCCS22 water supply pressure and flow rate for manual water makeup

2.2 Method

Implementing the automatic water makeup system required the level gauge in the surge tank, the additional air vent valves and solenoid valves with the accessories for control the water supply and apply the interlock. The demineralized water transfer line is already installed and connected. The revised piping and instrument diagram is shown in the Figure 5.

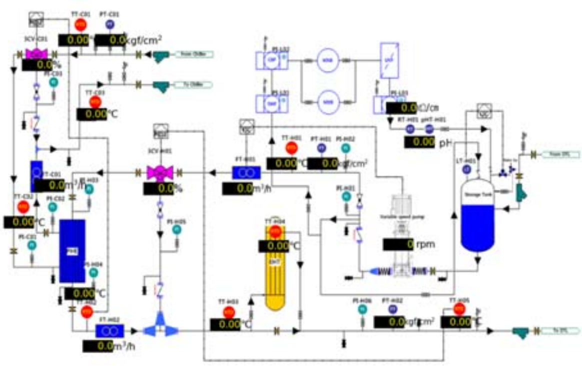

Fig. 5. RCCS's piping and instrument diagram [3]

The components were adjusted and installed including the level gauge with the float level controller, the air vent valve and the flow switch in Figure 6.

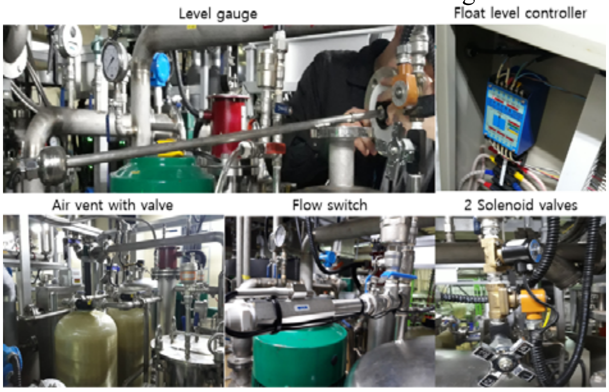

Fig. 6. RCCS component pictures

The operation logic is that when the high level signal from the level gauge is off, the solenoid valve in the water makeup line is fully open for providing the demineralized water into the surge tank. The high level signal is on, the solenoid valve will be close. If the flow switch on the over flow line is activated with a water detection, the solenoid valve 2 will be close for stopping water supply into the surge tank preventing the increase of water supply pressure to DTL tank. The logic is applied by using Allen Bradley PLC as below indicated in Figure 7.

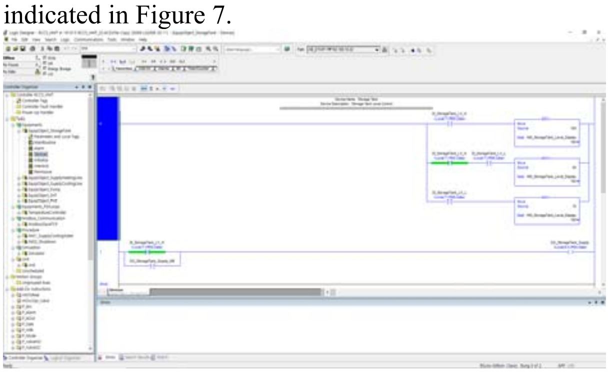

Fig. 7. PLC logic diagram

In addition, the safety interlocks were applied including the supply water pressure high, supply water pressure low, supply water flow rate low and even surge tank level low as a major alarm with RCCS trip for preventing any damage to DTL or RCCS.

2.3 Result

The automatic water makeup system is tested for 2 weeks. The water supply pressure and flow rate fluctuation is less within the acceptable ranges below 1% in the event of the water makeup. During the water makeup it takes 3 seconds between the solenoid valve is open and close shown in Figure 8.

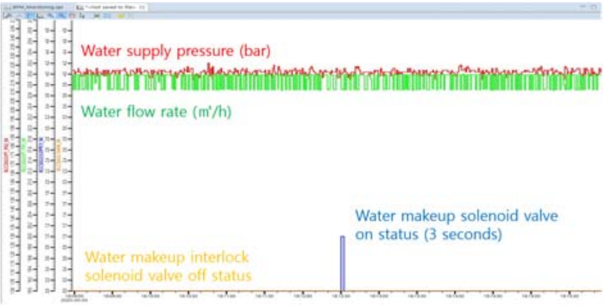

Fig. 8. RCCS22 water supply pressure and flow rate for automatic water makeup (6 min)

The water makeup happened about 32 times for 5 days. It means the water makeup is activated about 6.4 times per day as per Figure 9.

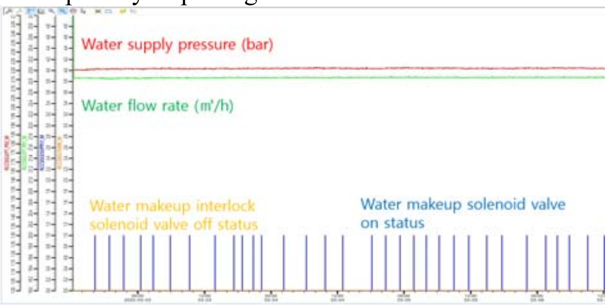

Fig. 9. RCCS22 water supply pressure and flow rate for automatic water makeup (5 days)

The standard deviation comparison between the manual water makeup and automatic water makeup is described on Table II.

Table II: Standard deviation comparison

RCCS 22	Standard deviation	
	Before	After
Water pressure (kgf/㎠)	0.022	0.014
Water flow rate (㎥/h)	0.108	0.135

It indicates that the water pressure standard deviation is reduced but the water flow rate is slightly increased.

3. Conclusions

The automatic water makeup test was finished and now RCCSs with this system are used to operate the DTL. During the test, the characteristics of this system were defined and the problems were solved. This system assists to keep the RCCS operation stability.

ACKNOWLEDGMENT

This work has been supported through KOMAC (Korea Multi-purpose Accelerator Complex) operation fund of KAERI by MSIT (Ministry of Science and ICT).

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