PRESENT STATUS OF BEAM COLLIMATION SYSTEM OF J-PARC RCS

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Abstract

The beam collimator system for the Rapid Cycling Synchrotron (RCS) of the Japan Proton Accelerator Research Complex (J-PARC) project is installed to reduce and localize the uncontrollable loss. The beam collimators suffer from the lost protons and induced secondary radiations. We need to design the collimator which took the influence of radiation into consideration. At the last PAC, we presented the cooling system and the remote clamp system design, which had considered the radiation influence. In this paper we show the test results of the heat transfer capacity of cooling fins and remote clamp system. The temperature of the horizontal collimator had exceeded 150 degrees C with 700W heating. The design was changed towards adding an air duct. About remote clamp handling system, we confirmed by the helium leak examination that it closed by 5.0E-10 Pa m3/sec or less helium leak.

INTRODUCTION

Japan Atomic Energy Agency (JAEA) and High Energy Accelerator Research Organization (KEK) have advanced construction of the J-PARC project. The accelerator complex consists of a 181MeV (at the first stage) or 400MeV (at the second stage) linac, a 3GeV, and a 50GeV synchrotron Main Ring (MR) [1]. The RCS ring accelerates a proton beam up to 3GeV and supplies it to the MR and the neutron production target. On the last target the RCS ring aims to generate a high power proton beam of 1MW at the repetition rate of 25 Hz.

The beam collimator system of the RCS is installed to reduce and localize the uncontrollable loss in order to keep the radiation levels to the hands-on maintenance level. Since the beam collimators suffer from the lost protons and induced secondary radiations, we need to design the collimator, which took the influence of radiation into consideration [2]. The cooling system of the collimator is designed by air-cooling in order to avoid radioactivation of cooling water. The pimary scatterer plate and secondary absorber blocks are connected to a copper heat conductor by Ag braging. The copper heat conductor is led out of the collimator vacuum chamber and the fin of 40 sheets is attached. The structure of the copper heat conductor and the fins were determined using the evaluated calorific value [3].

As well as recent high intensity proton facilities [4][5], our beam collimator system also has the remote clamp system to reduce the radiation dose during maintenance. The remote clamp system can connect and close (or open and separate) the collimator flange with other flange. All actions can be operated from remoteness by using the nut runners. Figure 1 shows the schematic of J-PARC RCS collimator.

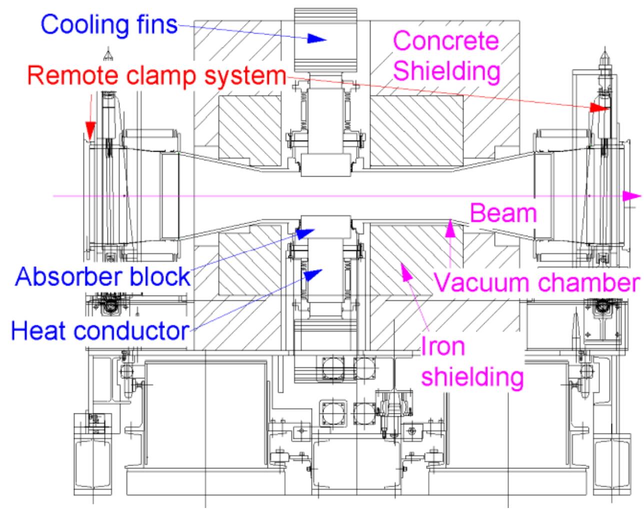

Figure 1. Schematic of J-PARC RCS collimator

COOLING SYSTEM TEST

At first the heat conductor of the cooling system was going to use the heat pipe system. But for the results of the irradiation experiment, it was clarified that the heat pipe was very weak to the radiation [6]. We reviewed the design and changed the conductor to the copper block. As a result of the estimate, the maximum loss per one horizontal absorber was 700Watt and the maximum loss per one vertical absorber was 400Watt, respectively. Figure 2 shows the result of the ANSYS simulation at the maximum calorific values. The simulation result shows that the collimator temperature can be kept less than 130 degrees centigrade by using the cupper conductor of 140mm diameter.

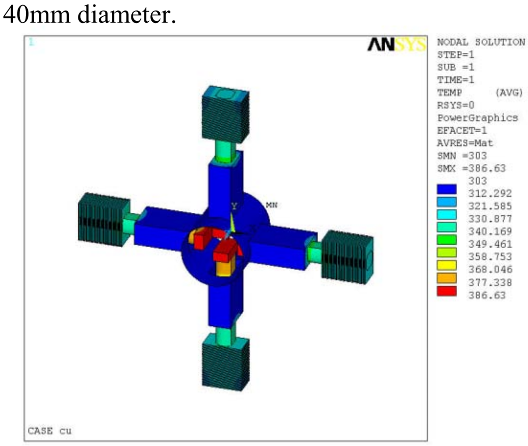

Figure 2. ANSYS calculation result

We tested the cooling capacity of this system by using the precedence machine. The experiment was conducted by the vacuum of less than 10^{-4} Pa. The heater was installed in the vacuum chamber and attached absorber. Figure 3 and 4 show the result of 700Watt and 400Watt heating. The temperature of the vertical collimator had been able to be kept about 130 degrees C or less with the design heat (400Watt, Figure 3), but in case of the horizontal collimator, the temperature exceeded 150 degrees C with the design heat (700W, Figure 4). Under such a condition, we tried forced cooling by the cooling fan and the temperature of the horizontal collimator fell below 120 degrees C. The cooling system design was changed towards adding a cooling fan.

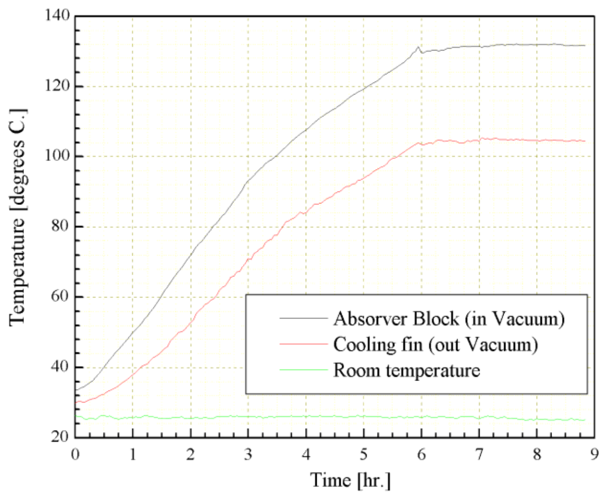

Figure 3. Cooling test at 400 Watt heating

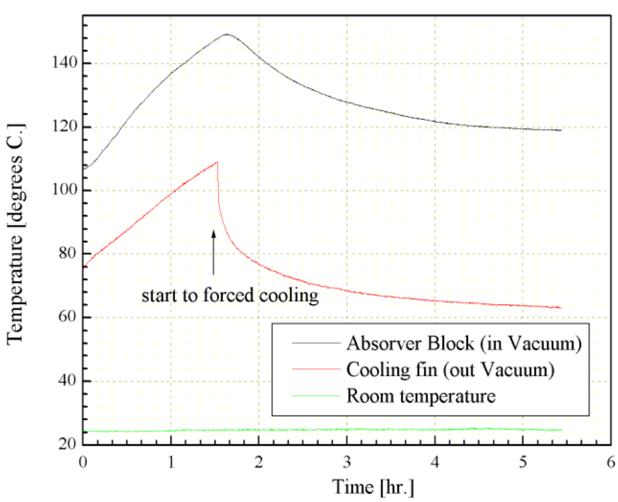

Figure 4. Cooling test at 700 Watt heating

REMOTE CLAMP SYSTEM TEST

By using the remote clamp system, the collimator vacuum flange can be connected/detached by merely turning a screw in a place away from the collimator. The quick-coupling clamp can be opened/closed by turning two screws that are connected with the clamp, and another screw separate/close the flange of collimator chamber and the flange of other accelerator component. The rotational number and the torque of all the screws are controlled by the nut runner, which is set by the crane. The clamp closing procedure is shown from Figure 5 in 7.

- First step : Set the nut runner on the flange separation screw from several meter away from the collimator chamber. (Figure 5 right)
- Second step : The nut runner close the separation of each flange. (Figure 6)
- Third step : The nut runner is remounted from the flange separation screw to the quick-coupling clamp closing screws.
- Fourth step : The nut runner controls the closing torque and rotational number and closes the quick-coupling clamp. (Figure 7)

The procedure for removing clamp and opening flange is the reverse of above-mentioned. After confirming all action, we checked by the helium leak examination that it closed by 5.0E-10 Pa m3/sec or less helium leak. Moreover, it was confirmed that the leak level was same even if the central axis of each flanges shifted by 1mm.

CONCLUSIONS

- We tested the cooling capacity of copper heat conductor. As a result, it is found that the horizontal collimator need additional forced cooling. The cooling system design was changed towards adding a cooling fan.
- We examined all motions of the remote clasp system. After confirming all motions, we checked the helium leak and there were no leak even if the central axis of each flanges shifted by 1mm.

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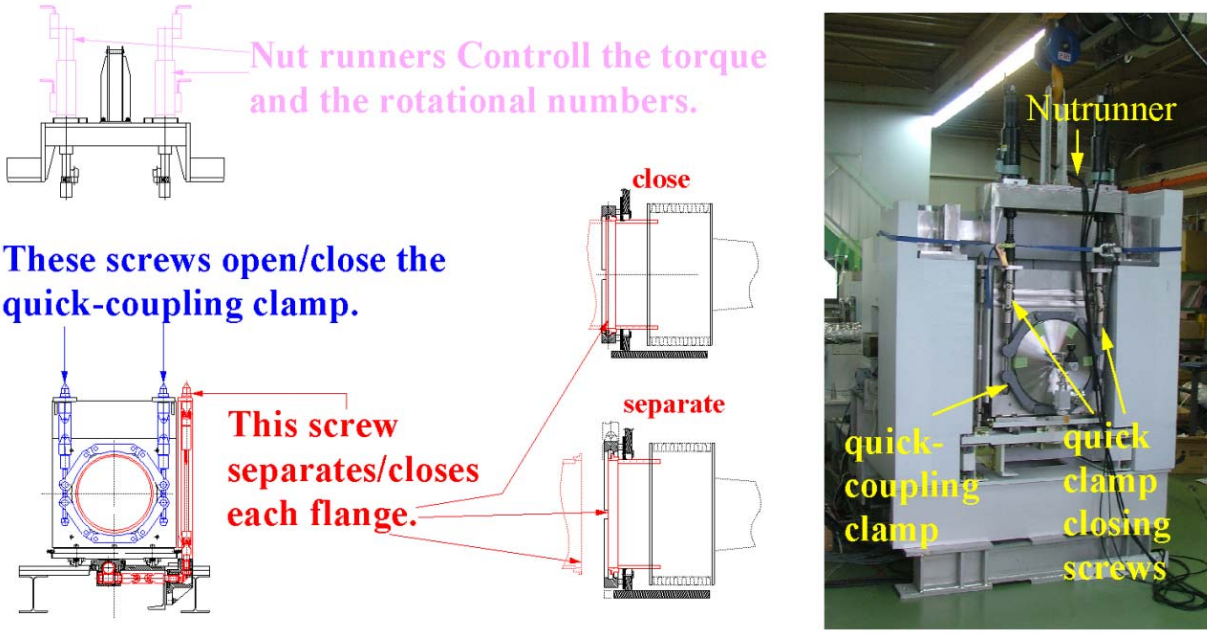

Figure 5. Schematic of the remote clamp system (left) and the nut runner setting (right)

In the left of Figure 5, the function of the remote clamp system is distinguished by the colours. The pink part represents the nut runner and it controls the closing torque and rotational number. The red part indicates the collimator flange and other flange, and the screw of the flange moving. Rotating this screw does the flange closing/separation. The blue part is the quick-coupling clamp and its screws. The quick-coupling clamp can be opened/closed by rotating these screws.

The right of Figure 5 shows the setting of the nut runner on the remote clamp system. The nut runner is put on the screw, which is wanted to move.

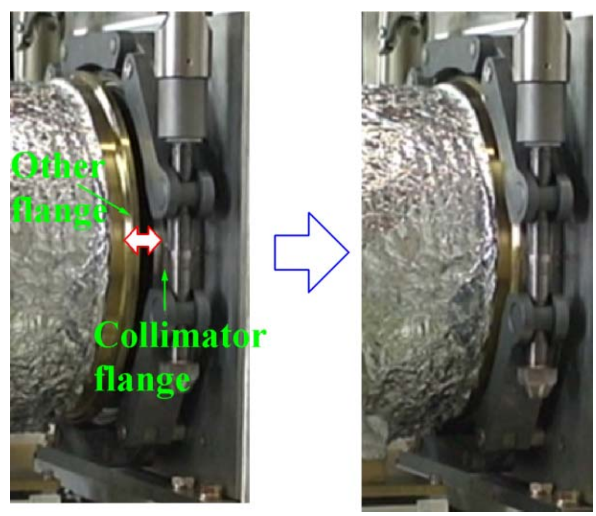

Figure 6. Close each flanges

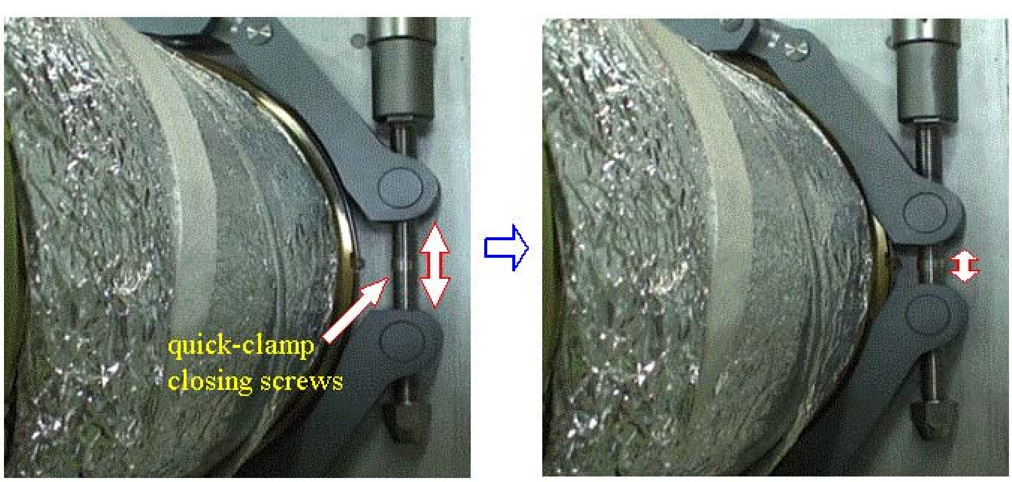

Figure 7. Close the quick-coupling clamp