DEVELEOPMENT OF BEAM COLLIMATORS FOR THE 1.6GeV RAPID CYCLING SYNCHROTRON OF CSNS

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Abstract

In order to reduce the uncontrolled losses in the localized station, the beam collimation system has been performed for the 1.6 GeV synchrotron of CSNS. The CSNS/RCS transverse collimation system is designed to be a two-stage system which consists of one primary collimator and four secondary collimators. Much work about machinery design and manufacture of the collimation system has been done till now. This paper will show the exterior frame of collimation system by considering the physical demands and spatial position. Then the progress which contains design and machining of collimators will also be introduced. Finally some problems which are mainly about the design of secondary collimators will be mentioned.

INTRODUCTION

The China Spallation Neutron Source (CSNS) is designed to provide a proton beam with the beam power of 100kW, and the accelerator complex contains a 80MeV negative hydrogen linear accelerator, and a 1.6GeV proton rapid cycling synchrotron (RCS) accelerator [1].

For hands-on maintenance of the high intensity RCS, we must keep the beam loss at an order of 1 watt per meter from the experience of former accelerator operation [2, 3], and a two-stage collimation system is designed to localize uncontrolled losses in a restricted area [4]. The collimation system consists of a primary collimator and four secondary collimators. The uncontrolled halo particles are firstly scattered by the primary tungsten collimator, and then they are absorbed by the secondary copper collimators. This report summarizes the development of beam collimator system of CSNS. In section 2 we present the exterior frame of collimation system by considering the physical demands and spatial position. Section 3 shows the present progress of collimators. Some problems about the design of secondary collimators will be mentioned in the last section.

EXTERIOR FRAME OF COLLIMATION SYSTEM

The collimation system is set at the right straight line of RCS (Fig. 1), in which the first one is the primary collimator, and the following four are secondary collimators. Additionally, two vacuum pumps are set between the last three secondary collimators to keep the condition of ultrahigh vacuum.

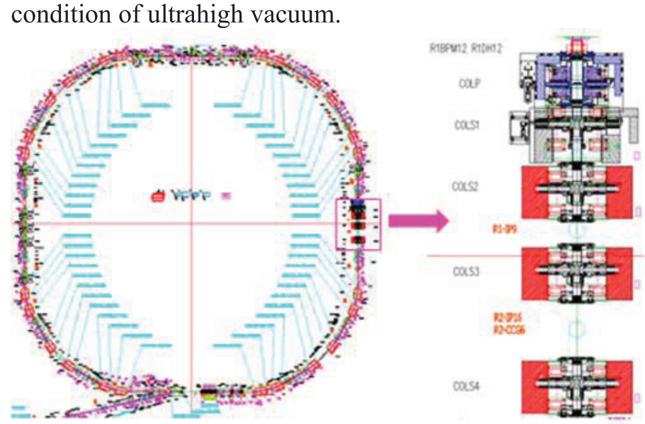

Figure 1: Schematic positon of collimation system.

The main structure of the collimation system is the scraper or absorber, each collimator contains four movable scrapers or absorbers, and they are set horizontally or vertically. The scrapers of primary collimator are made of 0.17mm tungsten slices, while the absorbers of secondary collimators are made of copper blocks. In physical design, the first secondary collimator will absorbs over 39% of beam loss, and then the beam loss which are absorbed by following three collimators decrease successively [5]. Although the four secondary collimators absorb different fraction of beam, the dimension of absorbers are designed to be same with each other.

The remote cramp system is another important structure for collimators to reduce the radiation exposure during maintenance. To remove vacuum chamber with bellows away from the upstream and downstream equipments, the primary collimator and the fourth secondary collimator must have remote cramp system, while the structure of the last three middle collimators can be determined as the case may be.

By considering the workload of design and manufacture, as well as the spatial position and maintenance, the secondary collimators are designed into two different structures (Fig. 2), in which the first secondary collimator doesn't have remote clamp system while others with same structure have remote clamp system. All of the step motors are set outside the concrete shielding.

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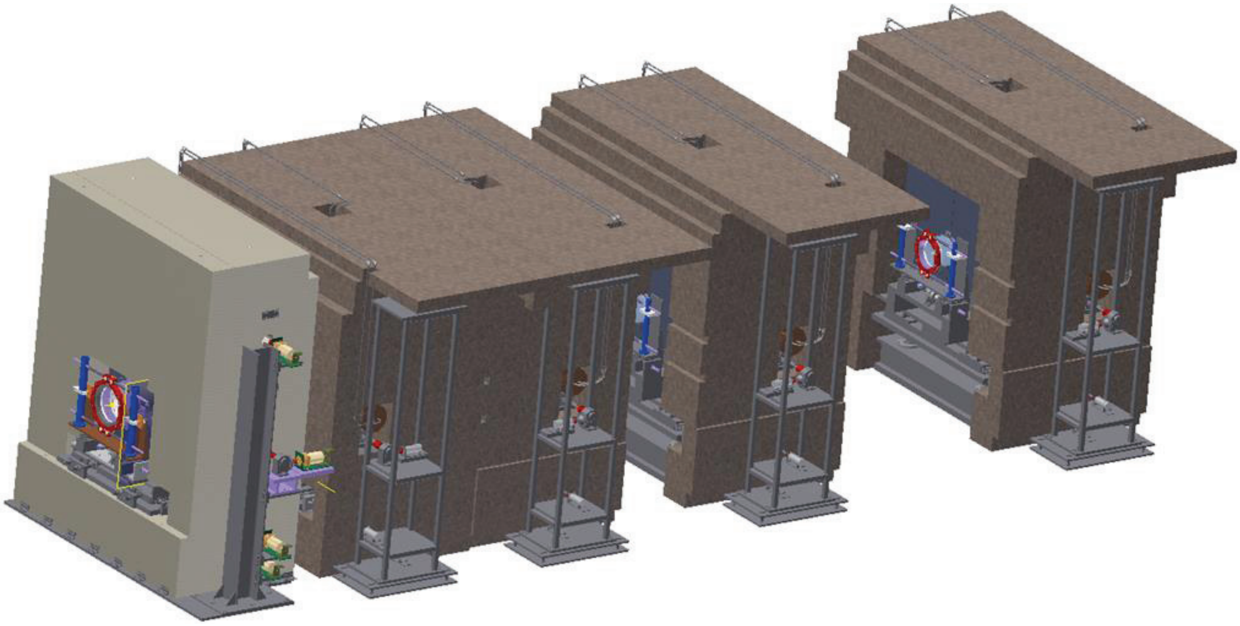

Figure 2: 3D model of collimation system.

PROGRESS OF COLLIMATORS

The mechanical design of collimation system was started since March 2010, till now most parts of the primary collimator have been manufactured, and the main structures have been pre–assembled (Fig. 3).

For the thickness of the scraper with high beam loss energy is only 0.17 mm, in order to conduct the heat from the environment of ultrahigh vacuum to out vacuum, a brazing process was designed for tungsten slice and copper block brazing, and then braze the copper block with copper conductor which connect with copper cooling fin to decrease the temperature by natural air cooling [6] (Fig. 4).

Figure 3: Pre-assembled primary collimator.

The thermocouple and feed- through are used to monitor the temperature of copper block in ultrahigh vacuum.

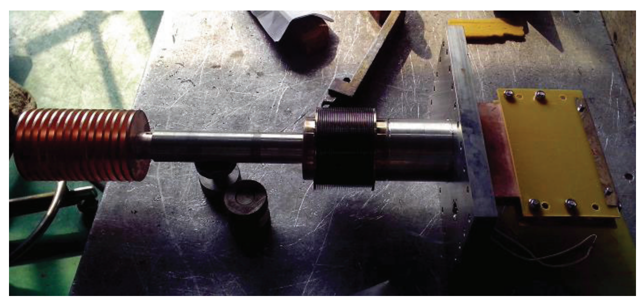

Figure 4: Brazing structure of scraper assemble.

Much work about the design of secondary collimators has also been done, including the absorbers, vacuum chamber assemble with two bellows (Fig. 5), support assemble (Fig. 6), cooling system and so on.

The temperature distribution is shown in Figure 7 when the maximum loss per one absorber is assumed as 500W as well as the bad natural air cooling. The simulation result shows that the maximum temperature is over 180 centigrade degrees, so the forced air cooling or water cooling must be considered. By comparing the simulation results with different parameters of air and water flow, the cooling system of secondary collimators is designed to combine forced air cooling and water cooling.

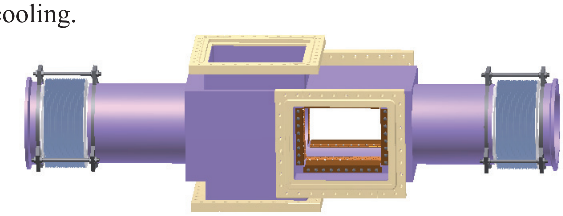

Figure 5: 3D model of vacuum chamber assemble.

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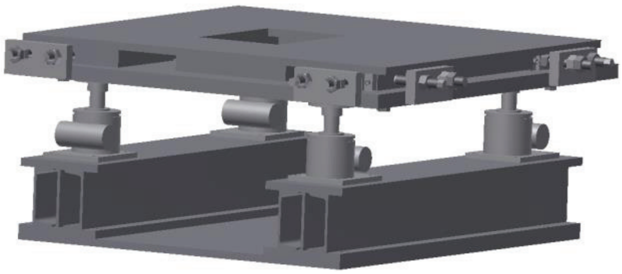

Figure 6: 3D model of support assemble.

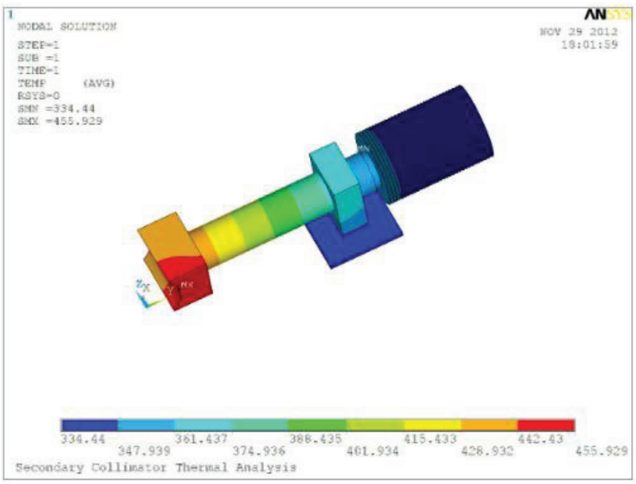

Figure 7: Calculation result about temperature

The thermocouple and feed-through are also used to monitor the temperature of absorber in ultrahigh vacuum, if the temperature in ultrahigh vacuum is over 150 centigrade degrees, forced air cooling or water cooling will be adopted, while which way to be adopted depends on the situation.

Figure 8 shows the detail structure of one secondary collimator, there still has much work about optimization design to be done.

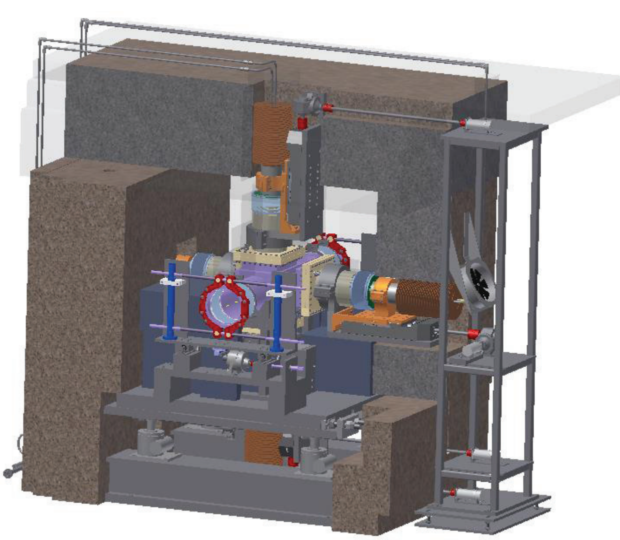

Figure 8: 3D model of secondary collimator .

PRESENT PROBLEMS ABOUT THE DESIGN OF SECONDARY COLLIMATORS

Although much work about the design of secondary collimators has been done, there are still some problems that need to be solved:

1. Considering the weight of absorber, linear bearing will be used to support it. With thermal expansion of the linear bearing at the temperature over 120 centigrade degrees, whether the absorber can move or not is still a big problem for the whole design.
2. For the nature air cooling is suitable in some case, with the beam loss energy is higher, forced air cooling or water cooling will be used, so optimization design of cooling system is necessary.
3. The weight of secondary collimator is nearly fifteen tons without concrete shielding, it is a big problem to hoist it in entirety and accurate location. They will be added when the final proceedings are produced.

REFERENCES

[1] S.Wang, S.X.Fang, S.N.Fu et al. Introduction to the overall physics design of CSNS accelerators [J]. Chinese Physics C, 2009, 33(2):1-3.

[2] N.Mokhov and W.Chou et al. Beam Halo and Scraping, the report of the 7th ICEA Mini workshop, Lake Como, Wisconsin, 1999.

[3] JHF Project Office. JHF Accelerator Design Study Report. KEK Report 97- 16, JHF- 97- 10, March 1998.

[4] T.Wei, Q.Qin. Design of the two-stage collimation system for CSNS/RCS[J]. Nucl. Instr. Meth. Phys. Res. A, 2006, 566(2): 212-217.

[5] N.Wang, S.Wang, N.Huang et al. The design of beam collimation system for CSNS/RCS*[C]// Proceedings of HB2010, 2010: 572-575.

[6] Y.Q.Zou, N.Wang, L.Kang et al. Thermal analysis and cooling structure design of the primary collimator in CSNS/RCS [J]. Chinese Physics C, 2013, 37(5):057004.