ALIGNMENT AND CALIBRATION FOR COLLIMATION SYSTEM IN CSNS/RCS*

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Abstract

In order to reduce the uncontrolled beam losses in the localized station, the beam collimation system has been performed for the 1.6GeV 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. All collimators had completed processing and now been installed in the tunnel. To meet the requirements of physical system, alignment for collimation system have to be done before circulating beams. This paper will show the alignment technique of collimation system. Then some problems during the alignment process will be mentioned. For the primary collimator will be replaced in second-stage of CSNS, the alignment for the replaced collimator will be introduced finally.

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 W/m 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 alignment and calibration of beam collimator system of CSNS [5,6]. In section 2 we present the installation environment and accuracy of collimation system. Section 3 shows the alignment of collimation system. Section 4 shows the calibration method and accuracy of collimation system. The alignment for the replaced primary collimator will be mentioned in the last section.

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*National Natural Science Foundation of China (Grant Nos.11375217)

INSTALLATION REQUIREMENTS 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 (colp), and the following four are secondary collimators (cols). Additionally, two vacuum pumps are set between the last three secondary collimators to keep the condition of ultrahigh vacuum of this area. To satisfy the maintenance requirement, all the equipment are surrounded by concrete shielding.

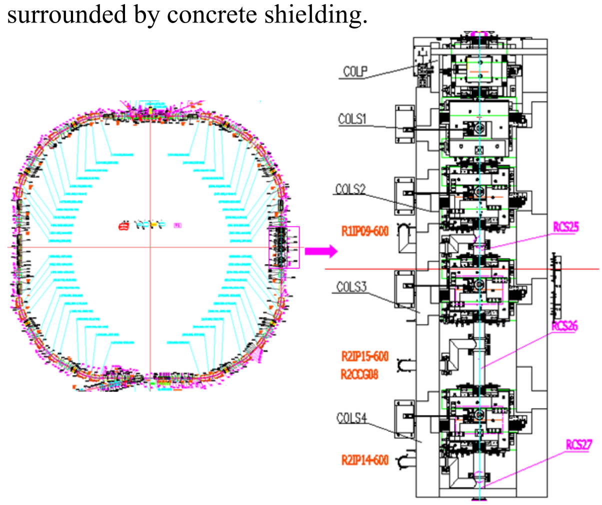

Figure 1: The overal layout of collimation system.

In order to satisfy the circulating beam requirement, each scraper should be moveable and meet the adjustment accuracy: (1) the positional accuracy should be less than 0.5mm; (2) the regulation precision should be less than 0.1mm; (3) the angular precison should be less than 1mrad.

Before the collimation system being installed in the tunnel, both the upstream and downstream equipments had been installed, only a little area left for collimation system alignment and calibration. To aviod the unnecessary job, each collimator should be installed one by one, after alignment of the vacuum chamber, each scrapers should complete to and fro motion, then the work of position calibration of each scrapers would be done.

ALIGNMENT FOR COLLIMATION SYSTEM

As shown in figure 2, all scrapers are connected to the vacuum chamber through rectangular flanges, and the square vacuum chamber in the middle area is the reference for scrapers installation.

There are ten basises of standard ball on each vacuum chamber component of collimators for alignment, after the vacuum chamber component completing processing, a coordinate system would be established based on the square vacuum chamber, the coordinates of the ten basises would be gotten through coordinate measuring machine (CMM)，and the data would be retested through laser tracker. For the basises on the square vacuum chamber will be surrounded by iron shielding, only four basises of F1-F4 can be used to locate the vacuum chamber, the alignment of collimation system contains two steps: (1) get the coordinate of all basises without top layer iron shielding, adjust the girder system to theoretical location; (2) assemble the top iron shielding, re-measure the F1-F4 coordinate, and fine adjust the girder, then the motor bracket is adjusted.

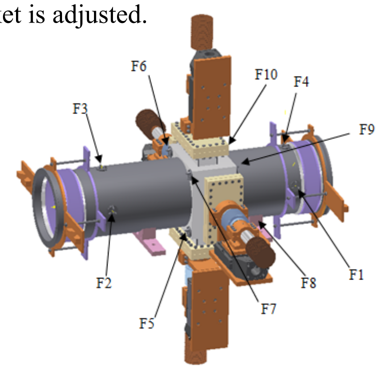

Figure 2: Vacuum chamber component of primary collimator.

CALIBRATION FOR COLLIMATION SYSTEM

Tungsten and copper are respectively used as the material for primary and secondary collimators' scrapers or absorbers (Fig. 3).

For tungsten is hard and brittle, and the thickness of the material choose for primary collimator scraper is only 0.17mm, the scrapers assembly is shown in figure 3, noncontact-measurement should be considered. The instruments of transit, level and laser tracker were used, and table 1 shows the accuracy of the instruments.

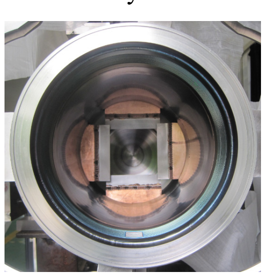

Figure 3: Primary collimator scrapers.

Table 1: Accuracy of the Calibration Instruments

Instruments	accuracy
Transit	0.02mm/5m
Level	0.025mm/5m
Laser tracker	0.02mm/5m

The laser tracker was firstly used to measure the basises to establish connection of primary collimator vacuum chamber and the RCS tunnel control network, for the basises out the iron shielding were on two ends of the vacuum chamber, the laser tracket couldn't get coordinate of all basises at a time, it would be set at one place and then moved to another place; then the device coordinate would be established; following the eight datum points would be placed for four scrapers in different directions, each scraper consisted two datum points, one for zero position and another for max position; the level and transit were respectively used to adjust the vertical and transverse scrapers finally, figure 4 shows the calibration scene of primary collimator. Calibration for primary collimator was a time-consuming process, it cost nearly three days.

Considering the error of measurer, the positional accuracy of the primary collimator scrapers was over 0.1mm, and less than 0.5mm, the regulation precision was less than 0.1mm.

Figure 4: Position calibration of primary collimator scrapers.

The absorber of the secondary collimators is made of a 200mm x 150mm x 120mm copper block, the assembly structure is shown in figure 5. High demand was brought up to the processing and assembly of the secondary collimators, the absorbers should be on the symmetry of horizontal and vertical planes of vacuum chamber center line, this work made the lowest point of absorber arc to be in the midplane.

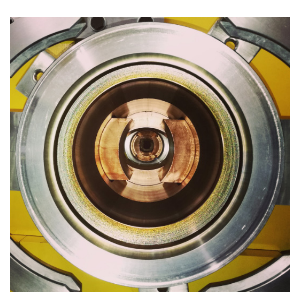

Figure 5 Absorber structure of secondary collimator.

ISBN 978-3-95450-182-3

To reduce the workload, and avoid the error caused by human, contact measurement was used, only laser tracker was used to calibrate the secondary collimators. To avoid polluting the inner-wall of the vacuum chamber, the action of putting the ball was done by a long pole. The object ball was set at the end of the pole, and staff could handle the pole out of the vacuum chamber to adjust the ball, the calibration of secondary collimator is shown in Fig. 5.

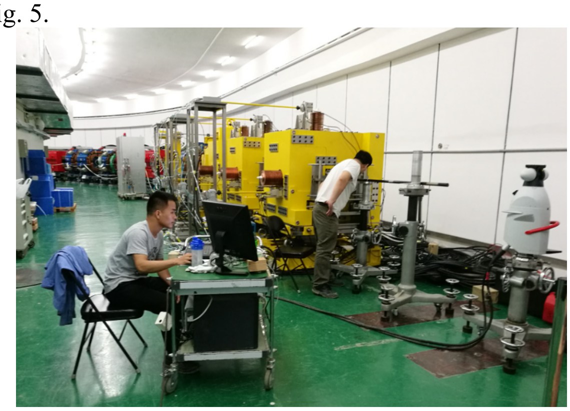

Figure 6: Position calibration of secondary collimator absorbers

In the calibration of secondary collimators, device coordinate should be established firstly, then got the points on absorbers of *X=0* or *Y=0*, and adjusted the location of absorbers at last. The positional accuracy of secondary collimators' absorbers was less than 0.1mm, and the regulation precision was less than 0.1mm too.

After all collimators being installed, the instruments of transit, level and laser tracker were used to retest the location of the scrapers and absorbers, only one absorber had a large deviation of nearly 0.7mm, the main reason for this error was mistaking the guard of object ball as the ball touched the absorber, zero position of the absorber was reinstalled, location retest of secondary collimators is shown in Fig. 6, and Fig. 7 shows the collimators with concrete shielding outside been installed

Figure 7: Location retest of secondary collimator absorbers

Figure 8: All equipment installed in place

ALIGNMENT SCHEME FOR THE REPLACED PRIMARY COLLIMATOR

As the primary collimator will be replaced in the second stage, and other equipment may not be replaced, only a little place will be left for alignment. To ensure the equipment be installed accurately, the primary collimator which was installed now was designed with four ball-sockets, as shown in figure 9, the parts on top of the balls will be replaced, and the new primary collimator will be processed with the scrapers precise positioning to the top ball-sockets.

Figure 9: Support system of primary collimator with four balls and four pair ball-sockets.

REFERENCES

[1] S.Wang, S.X.Fang, S.N.Fu *et al.* Introduction to the overall physics design of CSNS accelerators, *Chinese Physics C,* vol. 33, no. S2, p. 1-3, 2009.

[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,* vol 566, no. 2, p. 212-217, 2006.
[5] N.Wang, S.Wang, N.Huang *et al*., “The design of beam collimation system for CSNS/RCS*[C]”, in *Proc. of HB2010*, p. 572-575, 2010.
[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*, vol. 37, no. 5, 2013, p. 057004, 2013.

ISBN 978-3-95450-182-3