THE PRIMARY CONTROL NETWORK OF HLS Ⅱ

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Abstract

To meet the accuracy requirement of alignment and installation of HLSII, the high accuracy control network is necessary. The high accuracy primary control network will provides reliable reference to the local control network. After optimization design that using Monte-Carlo method, according to the structure characteristic of HLSII, the primary control network is measured by several different instruments, such as: Laser tracker, Total station and plummet. The accuracy of actual primary control network meets the design requirements; it provides strong foundation for subsequent project.

INTRODUCTION

Hefei Light Source（HLS）was designed and constructed in the 1980s, formal opened to outside in 1992. From June of 2012, on the basis of the NSRL, HLS had a major renovation, it is named Hefei light source-II(HLSII). The HLSII is a new state-of-the-art, low-energy electron storage ring (800 MeV) that delivers world-leading intensity and brightness beam with a 40 nm-rad minimum horizontal emittance. The HLS-II includes a 73.435 meters linac accelerator and a 66.13 meters storage ring [1].

According to the requirements of accelerator physics, location accuracy of components is better than 0.2mm. Meanwhile, the transverse location accuracy is better than 0.08mm for some important equipment [2]. It is a huge challenge for geodesy group of HLSII to achieve such a high accuracy at a large-scale space. To achieve the goal, a high accuracy primary control network is necessary.

By observing and calculating the control points which distribute in the linac tunnel and synchrotron ring, the relative position relationship of control points is obtained. The primary control network has two important functions, making sure the absolute relationship of linac and synchrotron ring and restraining the cumulative error of the local control network.

PLAN DESIGN

Based on the structure characteristic of HLSII, by consulting the design methods of other particle accelerators, triangulateration network is considered to be the most suitable option. By combined using several different instruments such as: Laser tracker, Total station, Level, etc. The optimal coordinate values of control points of adjustment are obtained.

Drawing Design

The datum points of initial building of Hefei light source are absolute reference all the time. It consists of seven metal pillars P01, P02, P03, P25, P26, P27, P28 that have forced centre devices and four datum points R01, R02, R03, R04 that are located on the synchrotron ring (as shown in Fig.1).

In the process of the upgrade, because of the obstruction influence and other reasons, some points can't be observed directly. By using the more advanced instruments and simplify the original primary control networks, the points that P01, P02, P03, P25, P26, P27, P28 are reserved, and a point is added at the middle of transport line. Then, according to the order, naming this points P1, P2, P3, P4, P5, P6, P7, P8. The line that connects P1 and P3 is X axis, P3 is positive direction. In the same way, the line that connects P2 and P4 is Y axis, P4 is positive direction. The point of interaction is original point, building a coordinate system. Plummet is used to project the points P5 and P6 that located in the transport line to synchrotron ring, naming them P5A and P6A. Taking no account of projection error, the coordinate value that P5, P6 and P5A, P6A are equal. Laser tracker is used to repeat survey the P1-P4, then we adjust them to reach the error range, building coordinate system, the coordinate value of P5A and P6A are obtained. Then total station is used to survey the primary control network of linac and transport (as shown in Fig.2).

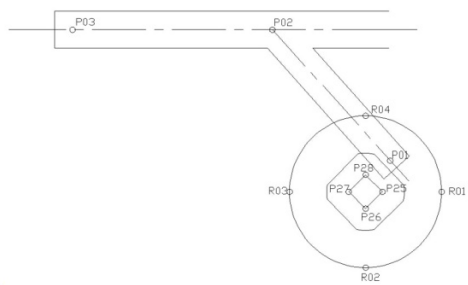

Figure 1: Layout of datum points of initial building.

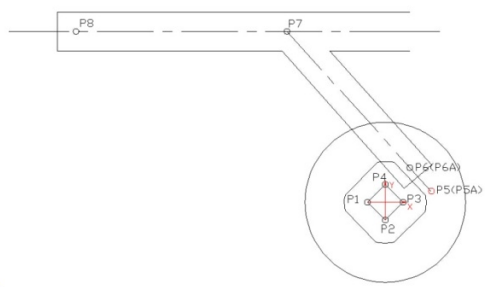

Figure 2: Layout of primary control network.

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Optimal Design of Primary Control Network

The accuracy of control network is determined by the RMS of weakest ranging or the RMS of weakest point. According to the design experience of control network and the observation of drawing design, the distance of P7 and P8 is beyond 80m, and without other points between them, P8 is possibly the weakest point and the ranging of P7P8 is weakest ranging. The guess is confirmed by the computer simulation later.

Simulation method of Monte-Carlo is used to produce a set of pseudo-random numbers, simulating a set of observation data and making a series of simulation experiences, finally an optimal solution can be obtained. According to the fact of HLS Ⅱ, adding one or two points between the P7 and P8, calculating and obtaining three different results about P8 (as shown in Table.1).

Table 1: The P8 Results of Optimal Design （mm）

Plan	M_X	M_Y	M_Z
No Points	0.64	0.72	0.96
Add P9	0.63	0.67	0.91
Add P9, P10	0.62	0.63	0.88

According to the Table.1, by comparing the error of P8 of different design plans, the accuracy of P8 that adding two points P9 and P10 enhances 10% than without adding points. The third plan is elected to be the final plan (as shown in Fig.3).

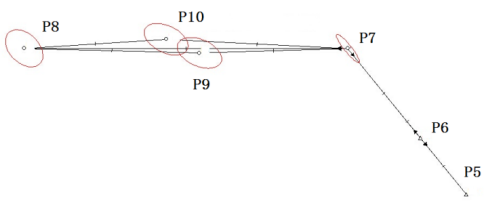

Figure 3: The error ellipse of primary control network.

ACTUAL MEASUREMENT

According to the structure characteristic of HLSII and the speciality of different instruments, laser tracker, total station, plummet and level are used jointly. From the June of 2012, the primary network was measured.

Distribution of Network Points

Cone design is adopted to match the Ø38.1 (mm) target bar, the bar diameter of different instruments are same, it benefits to exchange (as shown in Fig.4). Because of the error of machining, the actual touch is three points touch, and the positional repeatability is better than 0.01mm [3].

Figure 4: The target of primary control network.

Instruments and Software

The type of laser tracker is Leica LTD840, the total station is TDA5005, and the plummet is NL (as shown in Fig.5). In order to ensure the precision of this instrument, they were calibrated before measuring. The ranging accuracy of laser tracker is better than 0.03mm, and angular accuracy is better than 0.2″. The angular accuracy of total station is ±0.5″, the ranging accuracy is 0.5mm in the range of 200m. The plummet can offers a high-accuracy perpendicular, the accuracy of it is 1:200000[4].

The measurement software of laser tracker is Spatial Analyze, it is developed by NRK Company, and some instruments can work at the same time on it.

Figure 5: Instruments.

Actual Measurement

First, N3 level was used to measure the level of P1-P4, and adjusted them at the same level value. Second, laser tracker was used to measure the X, Y coordinate values of P1-P4. Third, the function of Best-fit was used to compare the measurement value with theory value, and adjust them. Repeating the second and third steps, the actual position of P1-P4 was similar to the theory. The line that connects P1 and P3 is X axis, P3 is positive direction. In the same way, the line that connects P2 and P4 is Y axis, P4 is positive direction. The point of interaction is original point, building a coordinate system. Because of the reason of actual naming, P5 was named TGA19. Plummet is used to project the points TGA19 and P6 that located in the transport line to synchrotron ring, naming them P5A and P6A. Taking no account of projection error, the coordinate value that TGA19, P6 and P5A, P6A are same. Then total station is positioned at the points TGA19, P6, P7, P8 to measure the ranging and angular. Because of the ranging of P7P8 beyond the 80m, in order to enhance the accuracy of network, adding two points between the P7P8, two points of local control networks named P9 and LWB21 were choose for saving costs. Four observation sets were measured by the total station (as shown in Fig.6).

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Figure 6: Actual measurement of primary control network.

ADJUSTMENT AND ACCURACY ASSESSMENT

The measurement data is analyzed after actual measuring, then making an indirect adjustment and accuracy assessment.

The error functions of range observation and direction observation are used to solve the primary network by the MATLAB. Accuracy assessment is calculated by the relative formulas.

Meanwhile, COSA software is used to test the results. COSA is developed by Wuhang University, and it also is commercial software. It is used to calculate the primary network and the result is compared with the result of hand computation (as shown in Fig.7).

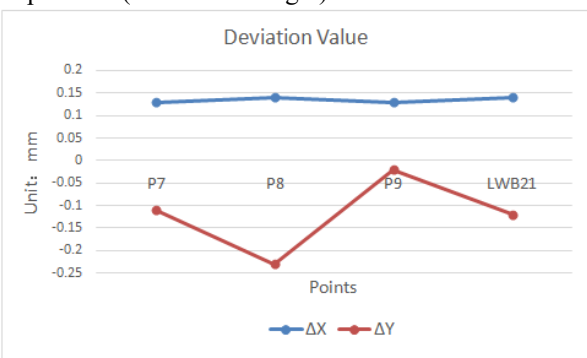

Figure 7: Adjustment results compare with COSA.

The biggest error of the DIF is 0.023mm. The error is allowed.

CONCLUSION

After a thoughtful arrangement, the project of HLS Ⅱ is successful; indirect adjustment is used to adjust the measuring data; the accuracy of the primary control network is meeting the requirement. The primary control network provides the global constraint for the project, and restraining the error accumulation of local control network, making sure the smoothing of the project. February of 2014, the light was success to lead, and it also proves the success of the upgrade project.

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