SURVEY AND ALIGNMENT FOR SSRF

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Abstract

The Shanghai Synchrotron Radiation Facility (SSRF) is a third generation synchrotron X-ray source, consists of a 300MeV Linac, 3.5GeV Booster and Storage Ring. The R&D of SSRF has been approved by the Science and Technology group of the Government, started early of 1999. This paper will describe the design of survey and alignment for the SSRF, including the control network, survey measurements.

1 INTRODUCTION

The Shanghai Synchrotron Radiation Facility (SSRF) is a third generation light source designed to produce high brightness and flux soft X-ray and hard X-ray in the energy region of 0.1~40keV. One of the most important factors in the successful operation of the machine is the alignment quality, which ensures the stability of the particle beams. The primary goal of the survey and alignment of the SSRF is to precisely align the magnets within 150μm of their designed position.To accomplish tasks a network of monuments is established and their positions are measured with respect to one another. Using the monuments as reference points, positions of magnets and other beam components are measured and alignment.

Uneven drop will occur in the storage ring floor due to different floor loading, ground moisture variations and seasonal variations. Therefore, monument positions and the magnet positions will have different changes.

The monument measurements and coordinate value calculations should be carried out periodically and the magnet locations surveyed and aligned at regular intervals.

2 ALIGNMENT TOLERANCES

In order to achieve a successful startup of the SSRF, the following relative alignment tolerances are defined by each of the ring managers.

Table 1: Maximum tolerable displacement for synchrotron magnets relative to adjacent beam components

	Dipole	**Quadruple**	**Sextuple**
In Beam Direction(ΔZ)	0.5mm	2mm	2mm
Horizontal(ΔX)	0.3mm	0.2mm	0.2mm
Vertical(ΔY)	0.5mm	0.2mm	0.2mm
Roll(Δθz)	0.2mrad	0.5mrad	1.0mrad
Pitch(Δθy)	0.5mrad	0.2mrad	0.5mrad

Table 2: Maximum tolerable displacement for storage ring magnets relative to adjacent beam components

	Dipole	**Quadruple**	**Sextuple**	**Injecting magnets**
Horizontal (ΔX)	0.5mm	0.15mm	0.15mm	1.0mm
Vertical (ΔY)	0.5mm	0.15mm	0.15mm	1.0mm
In Beam Direction (ΔZ)	2.0mm	0.5mm	0.5mm	2.0mm
Roll Angle(Δθ)	0.2mrad	0.5mrad	0.5mrad	1.0mrad

3 SSRF COORDINATE SYSTEM

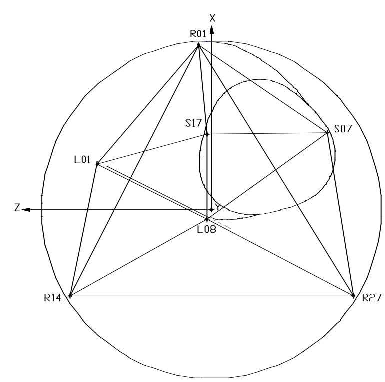

Fig.1: SSRF coordinate system and the sketch of the surface network

The absolute coordinate system (Fig. 1) is a right hand system originating at the center of the storage ring represented by O and with X-axis orientation paralleled to the direction through origin and the injector point, Z-axis is perpendicular to X-axis, Y-axis is parallel to the opposite gravity vector at O.

As the origin O is located under the LINAC tunnel, it’s impossible for us to set up a monument on it.

The local beam following system describes the orientation z at any point. It remains tangent to the beam trajectory s.

4 ALIGNMENT NETWORK

The SSRF accelerator consists of three main components: LINAC, booster synchrotron and the storage ring. In the LINAC the electrons are generated and pre-accelerated to 300 MeV (47 meter long), the acceleration to the final energy of 3.5 GeV is performed in the booster synchrotron (circumference 158.4m). The beam is then injected into the storage ring (circumference 396m). Together there are about 690 major beam components that are to be positioned in a great accuracy along the beam orbit. In order to accomplish the tasks, it is necessary to design and set up a net work which could keep the LINAC, synchrotron and the storage ring in correct position relative to each other and be references to the tunnel construction.

4.1 Surface control network

The Surface control network is made up of 7 concrete monuments (Fig. 1) embedded in the tunnel ground, 40mm lower than the tunnel surface in order to set up the tunnel monuments on it. Among them, two are the connections to the tunnel network in the LINAC (L01, L08), two are the connections to the synchrotron (S07, S17), the others are to the storage ring (R01, R14, R27). Windows on relative ratchet wall are prepared after tunnel constructed.

Total station instrument TDM5005 is used to measure the surface control network. For the vertical transfer technique, the precision optical plummet is needed. With a accuracy expecting program, an accuracy better than 1mm can be achieved with distance measured accuracy of 0.5mm and anger measurement accuracy of 3 sec.

4.2 *Tunnel network*

The tunnel network is made up of braced quadrilaterals through the tunnel of each accelerator subsystem. For the storage ring, the control network is expanded out to the experiment hall floor. Each ratchet wall of the storage ring has a removable shielding door which permits lines of sight between the control network inside to storage ring tunnel and experiment hall. In general the tunnel network will be used for the global positioning of all beam components in each accelerator subsystem. The monuments are imbedded in the concrete floor and the target is just above the floor surface. A side view is shown in Fig.2. The storage ring floor has 2 monument per sector for a total of 40 monuments.

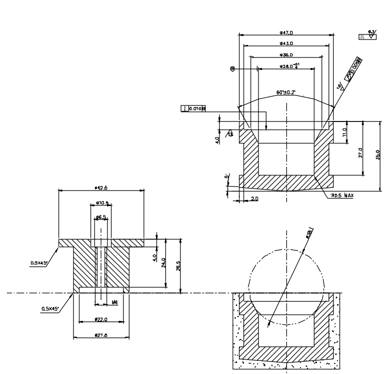

Fig. 2: A side view of tunnel monument

The tunnel network is measured by LTD500 with its software Axyz. The measurements are carried out in 40 stations nearby each floor monuments, shown in Fig.3.

4.3 *Elevation Network*

All tunnel monuments and reference points on the wall compose the elevation reference network schematically shown in Fig. 4, which is measured by the Wild N3 sight level and a relative accuracy (rms) better than 0.1mm is expected.

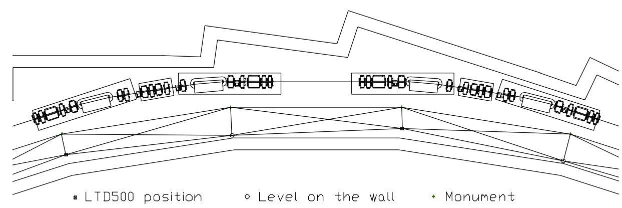

Fig.3: Tunnel network

5 MAGNET ALIGNMENT

All the beam components are measured with respect to known monument positions. Each quadruple and sextuple have four fiducial cups welded on top of the laminations for use in positioning. 1.5 inch LTD500 reflector is used as targets for these fiducial cups. During the magnet mapping process the location of each fiducial cup is determined using LTD500 reflector. On the top of the bending magnet laminations V-grooves are made in order to set up the movable jacket. The roll of the bending magnet is measured during the magnet mapping.

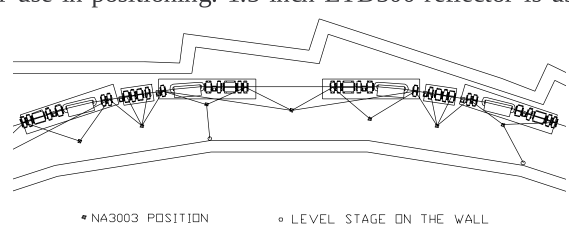

Fig.4: Elevation network

To perform the precision alignment, five-step procedure is applied.

5.1 Prealignment procedure for quadruples, sextuples and Bending magnets

For the purpose of matching the vacuum chamber section deviding scheme, a 3-girder system in one sector is used. All of the magnets and girders in one sector are grouped into 3 units.

The magnets, vacuum chambers and BPM which are put on the same girder will be prealignment in a preparation room, shown in fig. 5. With the work being done in a preparation room rather than in the tunnel, it can be carried out more efficiently, with higher quality installed and aligned in tunnel in a rather short period of time, thereby speeding up installation program of the storage ring

5.2 Mark the beam line on the floor

The position of Bending magnet and magnets on the end of each girder are derived from tunnel network control points using LTD500.

5.3 Rough setting Girder

Each prealigned girder is brought into the ring tunnel and roughly positioned by using the location marks. Then it is leveled using Wild N3. Tilt is controlled with a bubble level. A tolerance within ±2mm in relation to the neighboring reference points is expected.

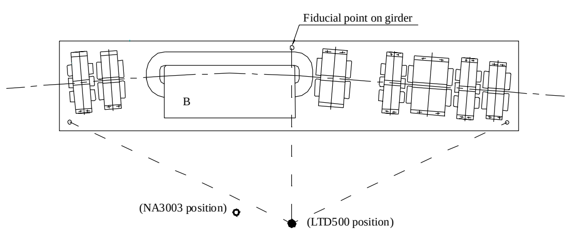

Fig.5 Prealignment for quadruples, sextuple and Bending magets

5.4 Fine positioning girder

Magnet positions on each end of the girder are measured and then adjusted to a rms 0.15mm of the designed position with respect to neighboring reference points utilizing LTD500. After that the girder will be locked.

5.5 Smoothing alignment

After girder realignment, a confirmation survey is carried out to determine whether the magnets are within the required tolerances. The survey is independent on the tunnel monuments, constituted from ring-quadruple itself. If the magnets are found to exceed the required tolerance the process is repeated.

5.6 Alignment of the LINAC

The Linac consists of electric gun, accelerating sections, the solenoids, the quadrupole triplets, etc.. These components mounted on each girder will be assembled , prealigned and fixed in the preparation room. The entire assembly will be removed into the linac tunnel and positioned roughly on marks on the floor. Finally by using LTD500 and linac tunnel monuments alignment system, the linac components will be aligned to the required accuracy.

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REFERENCE

[1] Survey and Alignment at the Advanced light source, Gary F.Kvebs， Lawrence Berkeley Laboratory

[2] Positioning the Spring8 Magnets with the Laser Tracker, C.Zhang, S.Matsui, J.Ohnishi, Spring8

[3] The Alignment of the Advanced Photon Source at Argonne National Laboratory, Horst Friedsam, Argonne National Laboratory