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ALIGNMENT OF MAGNETS FOR THE SPring-8 SYNCHROTRON

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Abstract

SPring-8 Synchrotron ring is composed of 64 dipoles, 80 quadrupoles and 60 sextupoles. The 80 quadrupoles and the 60 sextupoles are supported on girders. The circumference of the ring is about 400m. Since the tunnel of this ring is very narrow, SMART310, laser tracker for 3D measurements of moving targets, is used for the alignment. This paper will present the alignment method, results and present status.

1. Introduction

SPring-8 Synchrotron ring is under construction now. In June 1995, we began with the first survey of reference points for prealignment. We will finish the alignment of the magnets until January 1996. The alignment method is based on reference points inside the ring since there is no reference points outside the ring. This alignment consists of two levels. The first level is the network which survey and set the reference points of the prealignment for installing the magnets. The second level is the network for the precise alignment of the magnets.

2. Tolerances

The specification of the tolerance of the alignment is relative precision of ±0.2mm in radial direction, vertical direction and beam direction. And ±0.2mrad in tilt for the magnets. Table 1 shows the deviation of the relative precision of the alignment of each magnets.

Table 1
Deviation of the relative precision.

Magnet	Radial	Vertical	Beam	Tilt
Dipole	±0.2mm	±0.2mm	±0.2mm	±0.2mrad
Quadrupole	±0.2mm	±0.2mm	±0.2mm	±0.2mrad
Sextupole	±0.2mm	±0.2mm	±0.2mm	±0.2mrad
Correction	±1.0mm	±1.0mm	±1.0mm	±1.0mrad

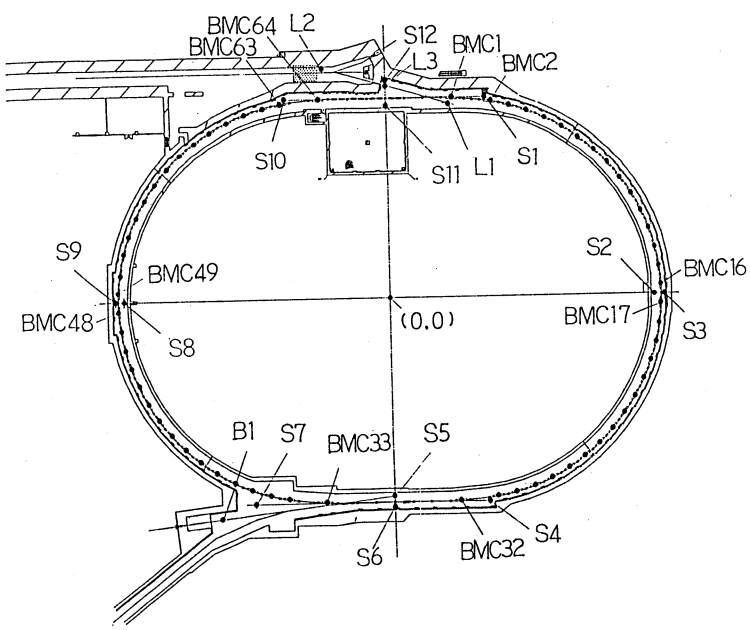

Fig.1 Reference points of SPring-8 Synchrotron

3. Alignment Method

3.1 Reference Points Setting

The first level of the alignment is setting the reference points for the magnets installation to the tunnel and prealignment. We survey the reference points and set them for the proper location.

Fig. 1 shows the reference points of the synchrotron ring. L1 and L2 which are on the injection line from Linac ensure the correct location and orientation of the ring. Based upon them, we set the reference points S1 to S12. These reference points are imbedded in the floor and are able to adjust the X−Y axis of the location. Monuments are set up on the points.

Using L1, L2 and other supplementary points, reference points of the straight line are set.

Since the Tunnel is very narrow and reference points are very few, it is remarkably difficult to realize highly accurate positioning of the reference points by triangle network calculation. For this reason, we use the center location of the 64 dipole magnets as supplementary points. Survey network comprises nearly 80 points of reference points and supplementary points. The objective of the first level alignment is that the deviation of the network calculation of the reference points is less than ±1mm.

The height reference is taken from the Linac injection line. Beam line is 1200mm height from the floor. This height reference is transferred to 1560mm height which is visible after the installing of the magnets. Nearly 10 height reference points like this are set up on the wall along the tunnel.

SMART310, theodolite, N3 and NA2 are used as survey equipment. Direction and Angle are measured by theodolite. Distance is measured with SMART310. Height is measured by N3.

3.2 Prealignment

At the reference points setting, supplementary points of 64 dipoles are simultaneously set, marked and inked on the floor. Magnets are installed in the tunnel according to this markings and inking.

The objective of this prealignment is as follows.

(1)Radial	±1mm
(2)Beam axis	±1mm
(3)Vertical	±0.5mm
(4)Tilt	0.2mm/m

3.3 Precise Alignment

Monuments are set on the reference points. SMART310, Theodolite, N3 and NA2 are used as survey equipment..

Reference points are measured with SMART310 for confirmation.

Fiducials on the 64 dipole magnets are used as supplementary points in order to obtain the accuracy of the network calculation. There are three fiducials on a dipole magnet. "BMU" means up stream, "BMC" means center and "BMD" means down stream. Sphere mounted retroreflector of SMART310 is positioned on the three fiducials.

According to the measurement data, magnets are correctly positioned.

Fig. 2 shows the precise alignment method of the magnets. Using the reference positions as reference, position of the three fiducials are measured. Using the previous data as reference, three fiducials of the next magnet are measured, and so on. After the survey is completed, each position is calculated by triangle network. If the result is not satisfactory, correct the position of the magnets and submit the network calculation again. This precise alignment is made in two rounds of the tunnel.

4. Instrumentation

Due to the narrowness of the tunnel, SMART310 is used for this alignment(see Fig.3). SMART310 is laser tracking system for 3D measurements. This is a single instrument for measuring angles and distances with automatic tracking of freely moving retroreflector.

The following is the instrumentation for this alignment.

(1) Distance
SMART 310 (Leica)
Accuracy
distance resolution ±1.26 μm
Inside Micrometer
1500mm Accuracy max.±0.04mm
5000mm Accuracy max.±0.115mm

(2) Direction and angle
SMART310(Leica)
Accuracy
angle resolution 0.7"

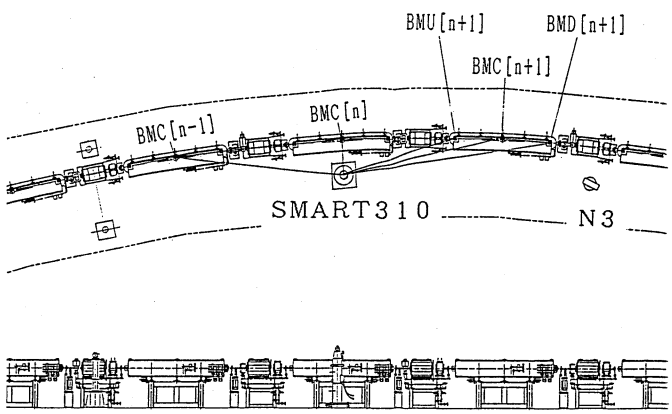

Fig. 2 Precise alignment method

Theodolite T2000, T2000S(Wild)
Standard deviation Hz: 0.5" ; V: 0.5"

(3) Height
N3, NA2(Leica)
Standard deviation for 1km ±0.2mm

(4) Inclination
DL−D3(Nigata seiki)
Accuracy 0.01mm/m

(5) Plumbing
ZNL(Wild) 1:30000

5. Results

In June 1995, we have finished reference points setting.

The deviations which is the difference between designed positions and calculated positions by network calculation were in the range of nearly ±1mm.

6. Conclusion

The alignment of SPring−8 Synchrotron is in progress now. 64 BMC's were set on the floor as marking. Applying these markings, positions of all components were inked on the floor.

In August and September 1995, according to the BMC markings and inking, magnets will be carried in the tunnel, and supports and girders will be fixed on the floor. Prealignment will be carried out after that.

Precise alignment will begin in November 1995. It requires three months to complete the second level of the alignment.

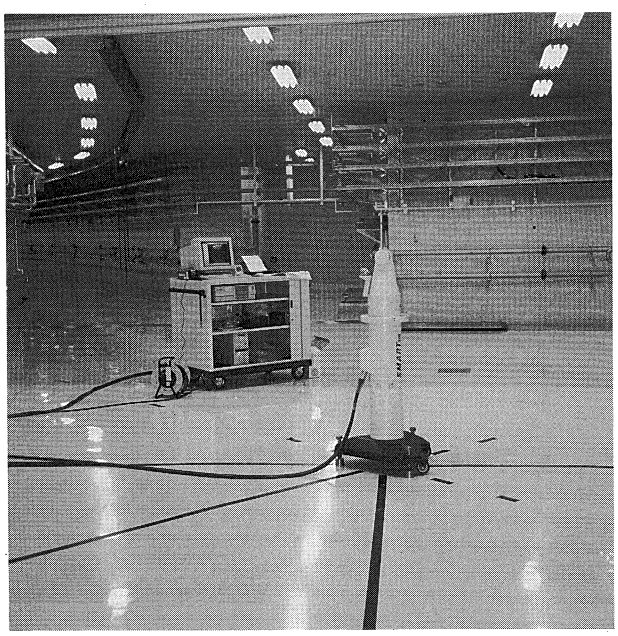

Fig.3 SMART310 System

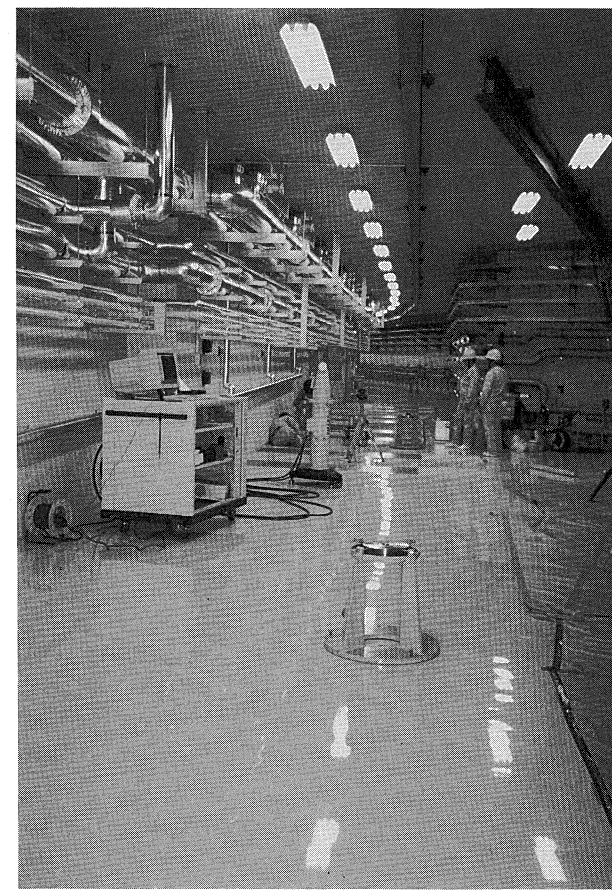

Fig. 4 Reference point and supplementary point setting