POSITION OBSERVATION FOR MAGNET UNIT AT SPRING-8

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Abstract

The position observations for the magnet unit of the SPring-8 storage ring are executed using the laser tracker for horizontal plane and the precision level N3 or DiNi11 for vertical plane. And, the measurements are carried on each year during the summer maintenance periods to monitor the changes. This paper will give a brief description of the survey methods as well as the results of measurements.

INTRODUCTION

The SPring-8 storage ring, with a circumference of 1.5 kilometres, is constructed mainly on hard rock or partly on artificial rock to ensure stable operation. The ring is Chasman-Green lattice of 48 cells. Each cell consists of two bending magnets and three magnet units, named a, b, c girder, which load seventeen multipoles. The positions of magnet units are measured each year during the summer maintenance periods to monitor their changes.

METHODS OF SURVEYING

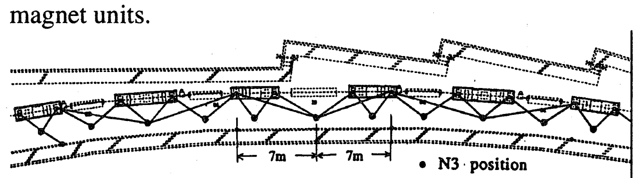
The storage ring tunnel is built surrounding the hill of Mihara-kuriyama. After tunnel construction the survey is completely isolated from outside. There is no absolute datum point (reference point) in the storage ring. Both of surveys for the horizontal and the vertical are relative measurements.

There are two fiducial points on one magnet unit at the two ends. Totals of 288 points at intervals of 5 meters averagely in the storage ring. Both the horizontal and the vertical surveys are measuring the positions of these fiducial points.

Nowadays the laser tracker (LT) is widely used in metrology and accelerator alignment. Since the beginning of 1994 we have being used the LT of Smart 310 for survey and magnet alignment [1][2]. The system measures distance with a laser interferometer, and the horizontal and vertical angles with two encoders. According to our experiments, the distance resolution is about 1.3μm. But the angular measurement is relatively inferior and around 2 arc seconds at our working environment. Therefore, the surveys are divided into the horizontal and the vertical, using the LT and precision level respectively.

Surveying for the vertical

Before 1999 the heights of magnet units were surveyed with Wild N3 (standard deviation (std): 0.2mm/1km). Because it is an optical instrument the surveyor usually feel tired from too much observations. And, the measurement result is more or less depends on people's eyes. Since 2000 we have being used the digital level Zeiss DiNi11 (std: 0.3mm/1km) for level survey. In the measurement the instrument is set in the middle of two measuring points and measure the height difference between them. To reduce measurement error the height difference is measured not only for adjacent points but also for the points leaped over two points. Total observations for height differences are 384 in the storage ring. Fig.1 is the survey network for the levels of the magnet units.



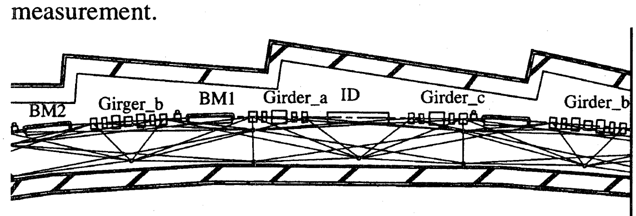
Std. (Between units): 0.02mm
Error rms (For 1.5km ring): 0.2mm

Fig.1 Survey for the levels of the magnet units.

Surveying for the horizontal

In addition to the fiducial points on the girders the observation for the positions of magnets in the horizontal needs some auxiliary points on the wall. Unlike the vertical, which has equipotential surface, the survey in the horizontal has no absolute reference datum. Therefore the survey accuracy depends on the survey method and the network.

The survey network, as shown in Fig.2, is basically composed of distance measurements between the targets. The LT is set station by station continuously along the ring. Averagely the LT measures 8 or 9 points from one station. After one set of measurement the LT is moved forward by about 7.5 meters and made another set of measurement.



Line: distance measurement; Circle:station of LT set up.
Std. (Between units): 0.05mm
Error rms (For 1.5km ring): 0.5mm

Fig.2 Scheme of survey network for the horizontal.

As mentioned above the LT gives three independent elements of a distance and two angles. To take advantage of the LT, we usually make use of 'direct-distance' as many as possible because of the inaccuracy of the angle measurement. The direct-distance means the distance from the mirror of the LT to the targets, which is measured by the interferometer. On the other hand the indirect-distance means the distance deduced from the coordinates of points. When measure indirect-distance the LT should be set as near as possible to the extension line of the two measuring points to reduce the influence of LT's angular errors. Presently, we usually adopt the "Direct distance measurement method", which was first employed in the alignment of the NewSUBARU ring [3]. In such case, we use only direct-distances [Fig.3] to survey and determine magnet positions. The distances are needed to project onto the measuring plane of the horizontal when calculating point positions.

The positions of measurement points are resolved with the adjustment computation method of least squares.

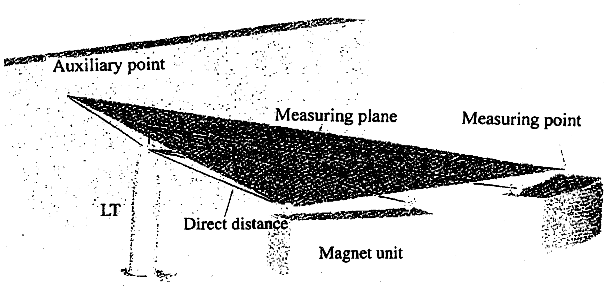
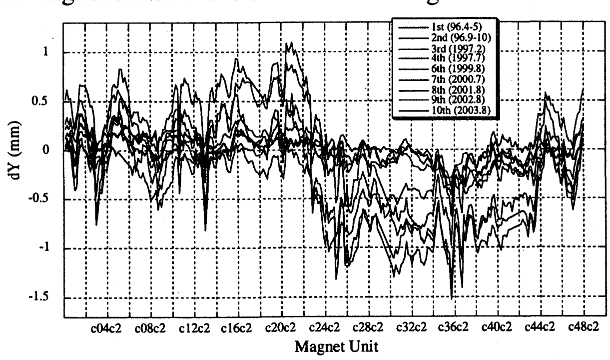


Fig.3 Direct-distance measurement method in survey

RESULTS OF POSITION OBSERVATION

Since the construction of the storage ring the positions of magnet units are surveyed regularly to monitor their changes. Fig.4 is the survey results for the levels. Because the measurement is unavoidably has errors and there is no datum point the ring, to make a comparison between surveys we fit the data to smoothing curves of locally weighted least squares. Consequently the displacements of magnet units in levels are shown in Fig.5.



C2 indicates the second point on the c girder.

Fig.4 Survey results for the levels of magnet units.

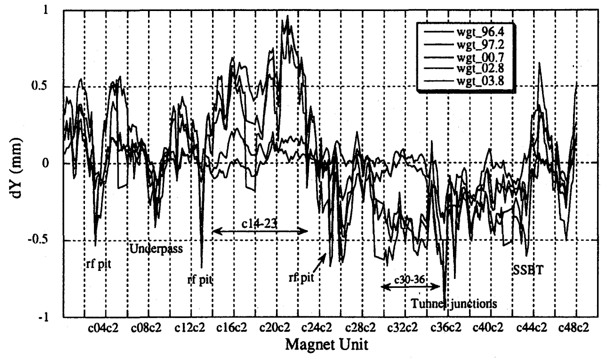


Fig.5 Displacements of magnet units for the vertical.

The consistence of magnet levels is still in ±1mm according to recent measurement. Some areas that have special underground structures show apparently large changes. Table 1 lists the level variations for some typical areas and the probable reasons.

Table 1: Level variations for some typical areas.

Cell No.	Change amount	Underground struct.
C1,3,13, 25,37	-0.5 mm	RF pit
C9	-0.4 mm	Underpass
C36	-0.8 mm	Boundary of construction zones
C43	-0.3 mm	SSBT transport line
C30-36	-0.5 mm	Artificial rock
C14-23	+0.4~0.8 mm	Soil-removed area

Generally, There are subsidence in the places where have underground pits, so are the areas that ground was improved with artificial rock when constructing the tunnel. Moreover, some of the areas that were constructed on hard rocks are observed on upward trend. That is comprehensible for the area between cell14 and cell23 where the hill was removed and the rock was cut to the same altitude as others when building the tunnel. It is considered that reduce of the mass causes geographic surface increase. Comparatively, the area of cell 37 – 43, where is also built on hard rock, has no the trend of surface rise.

For the horizontal the survey results are showed in Fig.6. Maximum displacement in horizontal transverse is still in ±1.5mm after many years. To make a comparison between measurements the data are removed for low frequency components by locally weighted fitting and are showed in Fig.7. It is need to say that the measurements at four long straight sections (cell6, 18, 30, 42) have large error because of the change in survey network after the long straight sections were introduced in 2000.

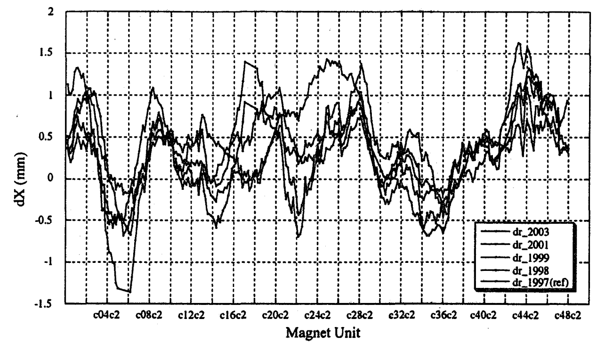


Fig.6 Survey results for the horizontal of magnet units.

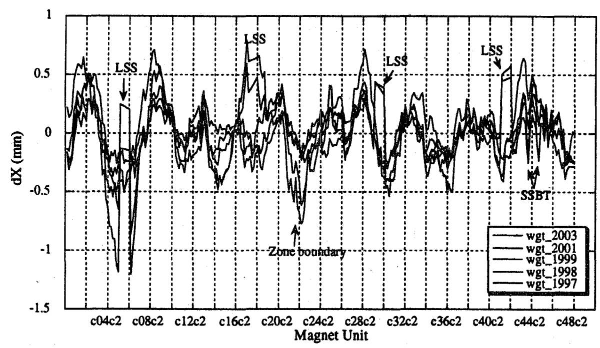


Fig.7 Displacements of magnet units for the horizontal transverse.

Globally there are no tremendous position changes for the horizontal transverse since 1997. By comparing with fig.5 one can see that most of the displacement peaks in the horizontal are in correspondence with that of the vertical. That is, the displacements are mainly due to ground movements and related to the monument positions. Those monuments were built under the bending magnets and were surveyed in 1993 before the construction of the tunnel [4]. They were buried into the tunnel ground afterward and used as position references in 1995 in the process of magnet alignment. There is a possibility that the positions of these monuments had been changed from 1993 through 1995 when building the tunnel. These changes should be in a same tendency as that of the levels.

If we examine the relative displacement between magnet units, Fig.8 gives the results in 1997, 2001 and 2003.

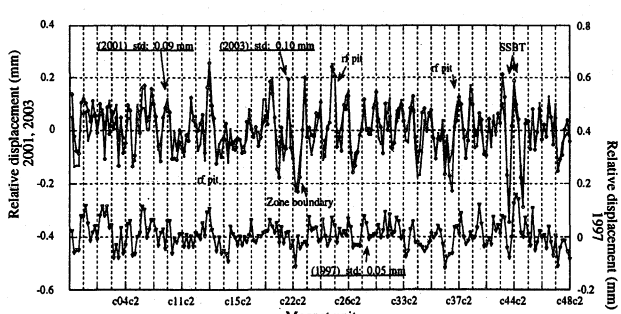


Fig.8 Relative displacements between magnet units in horizontal transverse.

The standard deviation between girders has increased from 0.05 mm rms in the beginning of 1997 to 0.10 mm rms at present. However, there was little change in past two years. For the displacements, some particular places (rf pit, SSBT, zone boundary) still can be seen for the large variations. Another result is that the displacements are in short periods with similar pattern. And, the deterioration of the girder C is mainly toward outside of the ring. This phenomenon may be related to the vacuum farce, which is caused by different areas at the two ends of bellows. The force is about 0.8 ton and executes onto the girders through the fixtures between chamber and girder and made the girder twisted and moved. We are doing further investigation about this matter.

CONCLUSION

The position observations for the magnet unit of the SPring-8 storage ring are executed using the laser tracker for horizontal plane and the precision level N3 or DiNi11 for vertical plane. The standard deviations of them are 0.2mm and 0.5mm respectively.

Maximum displacements are within ±1.5mm for the horizontal transverse and ±1mm for the levels although many years have passed. Some areas that have special underground structures show apparently changes. Generally, There are subsidence in the places where have underground pits, so are the areas that ground was improved with artificial rock in constructing the tunnel. Moreover, some areas that were constructed on hard rocks are observed on upward trend. For the relative displacement between magnet units, standard deviation has increased from 0.05 mm rms to 0.10 mm rms. However, there were little changes in past two years according to resent observation.

ACKNOWLEDGMENT

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