Magnet Alignent Results of the SPring-8 Storage Ring

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Abstract

The magnets alignment of the SPring-8 storage ring was completed at May 1996. After one year relative values between the girders was 0.05 mm in horizontally and 0.06mm in vertically. The deviation of multipole magnets from the straightness was about 20μm in a girder.

1. Introduction

The storage ring has 1436m circumference which surrounds the 50m-high hill. Each cell has 10 quadrupole and 7 sextupole magnets on 3 girders, and 2 bending magnets.

Twenty-one monuments in whole ring were surveyed before tunnel construction with a distance meter (Kern ME5000) and two ceodlites (Wild T3000). These monuments were used as reference points. After tunnel construction these monuments and other 67 ones were surveyed by laser tracker (Leica SMART 310) and the ceodlites by making network. The marks for baseplates were made by the laser tracker. After this the girder was set on the baseplates and multipole magnets were put on the girder.

Two target stages have been fixed after fine adjust at the 500.00mm above the magnetic axis at magnetic field measurement on both end magnets as shown in Fig.1.

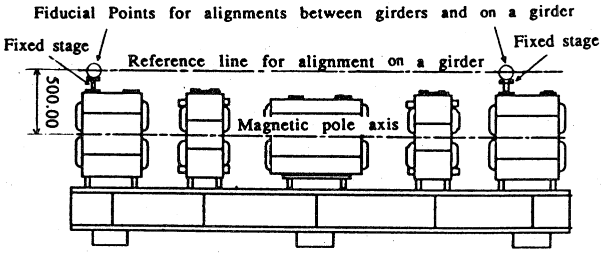

Fig.1. Alignment reference line and magnetic pole axis.

After pre-alignment both the end magnets were surveyed by the laser tracker, and then girders were smoothed.

Bending magnets were aligned using these aligned points.

Five or seven multipole magnets on the girder were aligned precisely using a laser and CCD camera system and tiltmeters (Taylor Hobson Talyvel4).

2. Alignment between girders

2.1 Horizontal plane

Since the girder number is 144, survey points are 288. After first alignment, the multipole magnets were half-divided and restored to install vacuum chambers. Vacuum chambers were baked, which supports are mounted on the same girder as magnets. Temperature was not uniform in the period of magnet installation, maximum 15 degree change. The girder is fixed to the baseplates at 6 legs. Since the length is 4 or 5 m, thermal expansion is large. Thus the shifted values of girder were larger than expected. Transverse relative deviation (1 σ) between girders changed as follows:

1996.3	40 μm	just after alignment
1996.10	56	
1996.11	40	After 27 out of 144 girders adjust
1997.2	45	(Fig.2) (1997.3 ring commissioning)

Fig.2 is obtained by a distance and angle combined survey. Vertical lines represent error bars of the absolute displacements. Angular measurement between girders is necessary to reduce transverse displacement as a whole, but it does not affect relative positions between girders in our case. One can see that displacement in radial direction is 1.4 mm maximum for the ring and 0.37 mm on average.

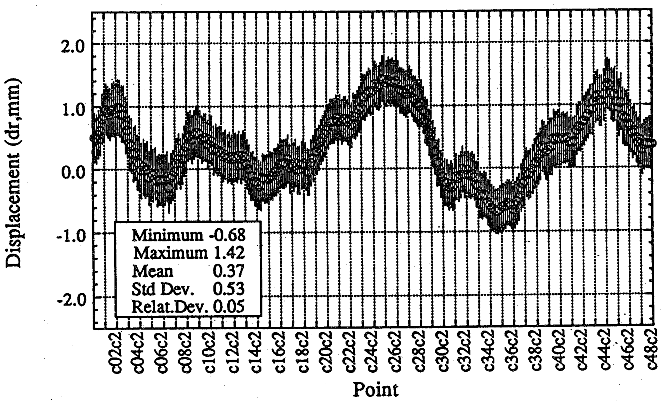

Fig.2 Horizontal transverse displacements of girders.

2.2 Circumference measurement

The laser tracker was used to measure the circumference. The result was 1.9mm(1.3ppm) longer than designed value, and the one calculated from RF frequency was 2.2mm.

2.3 Vertical

Magnet levels were surveyed four times. Fig. 3 shows the changes between the two surveys and the last level. The level difference between far apart two points is not reliable.

The elevation at the 10 m long underpath for vehicle rose up to a maximum of 0.4 mm during the summer and decreased by 0.4 mm during the winter because of ambient temperature changes. The floor levels over underground drain pipes of 0.9m diameter at five locations changed from ±0.1 to ±0.2 mm in the same way. Since both ends of this pipe were opened in the air, the floor over the pipe section was warmed and cooled. There are two points which change reason is unknown.

The floor over the RF wave guide room settled and is now deforming depending on the temperature in that room.

The length of the section over the transport line from synchrotron to the storage ring (SSBT) is about 7 m. The concrete thickness of this floor is 1.4 m. The floor level change of this area was within 0.2mm.

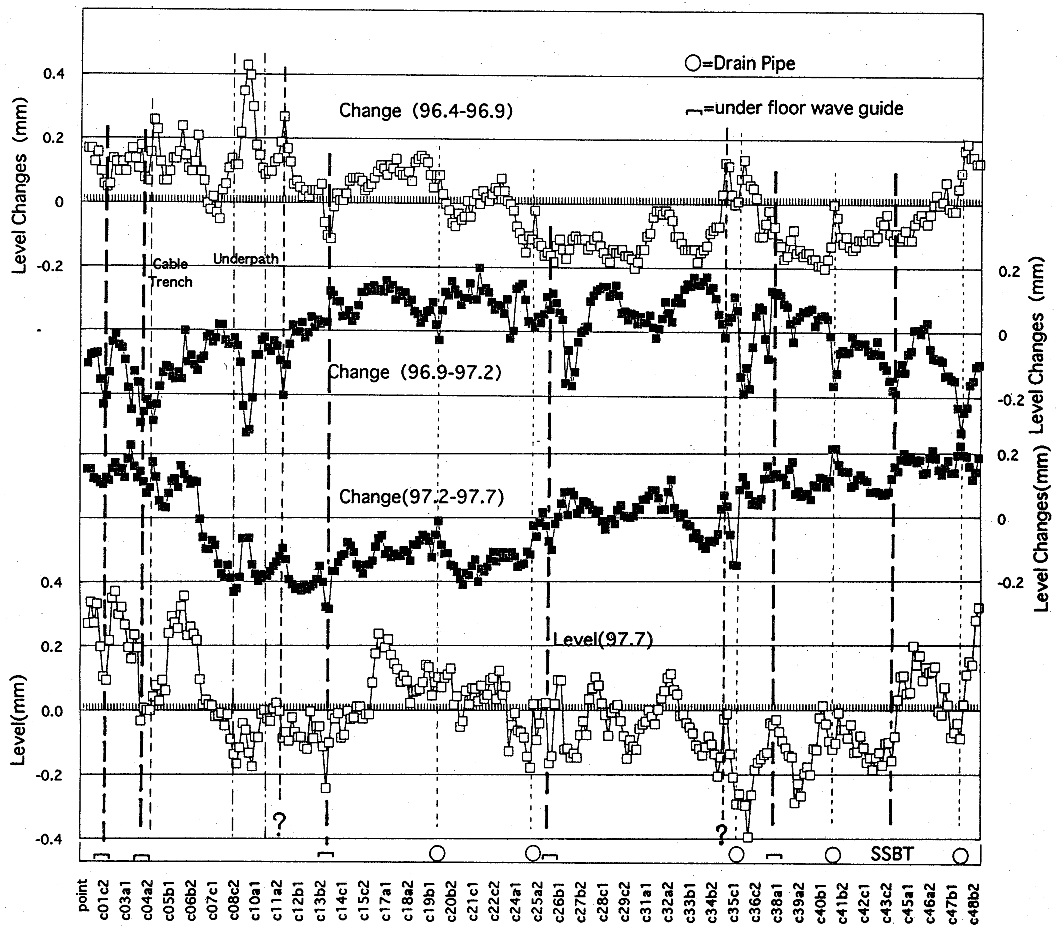

Fig.3. Level changes and the last level of the girders.

3. Alignment of bending magnet

Bending magnet were aligned with the laser tracker and tiltmeters(Leica Nivel 20) put on two fiducial planes. These bending magnets are pulled to down-stream direction remarkably by the vacuum force (800kg) which comes from the asymmetric cross sections of the bellows. Thus the average value of s-directional displacements was 0.26mm shown in Fig.4. Eight magnets were re-adjusted. Since the stress point is edge of the magnet, the magnet rotates (Fig.5) and slightly twists. (Fig.6)

The fiducial plane inclined for 140 μrad by magnetic force. Thus it was better to take account of this when aligning.

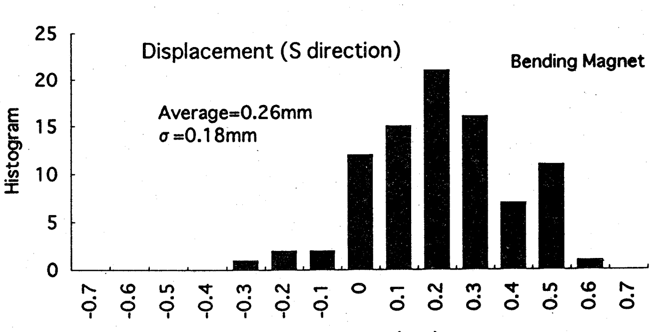

Fig.4. S-directional displacements of bending magnet.

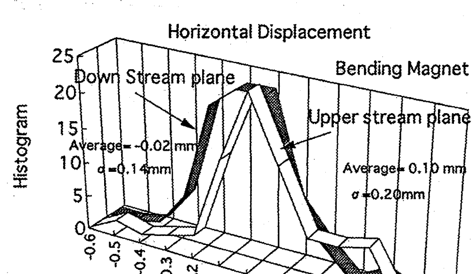

Fig.5. Transverse displacements of bending magnet.

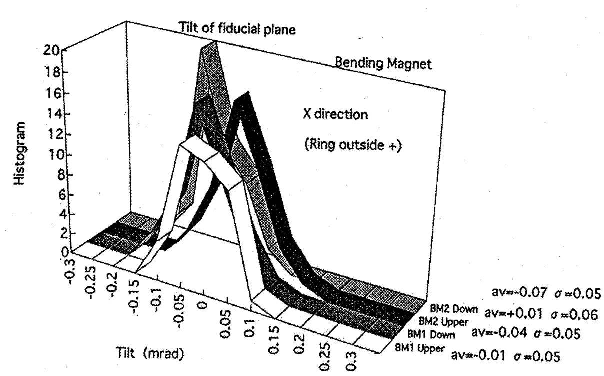

Fig.6. Tilts of fiducial planes of bending magnets.

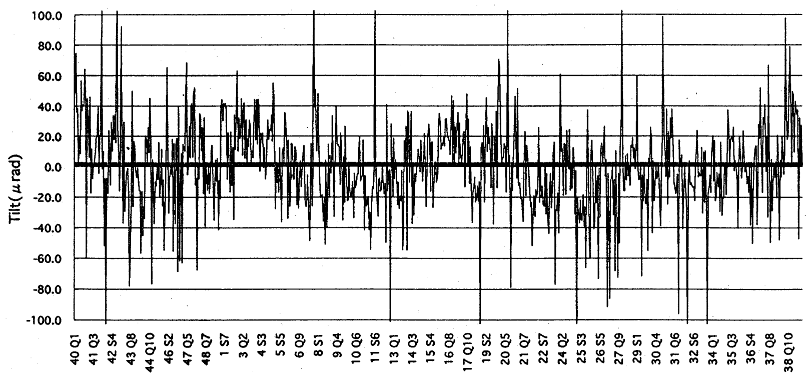

Fig.7. Tilts of all multipole magnets.

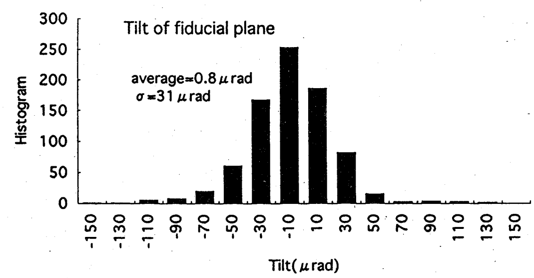

Fig.8. Tilts histogram of multipole magnets.

4. Alignment in a girder

Fig. 7 shows the whole ring tilt of fiducial planes of multipole magnets in July 1996. The reproducibility of fiducial plane tilt was not good for the two types of quadrupole magnets after divide and restore. Thus the fiducial plane tilt which exceeds 80 μrad does not agree with the magnet tilt. Fig.7 also suggests that the floor tilt changed after alignment. Fig.8 shows the tilts histogram of fiducial planes.

The standard deviation of alignment error in a girder were about 6 μm in horizontal and vertical directions just after the alignment. However after divide and baking etc., the displacements also got worse.(Fig.9,10).

The distribution of s-directional displacement was not good because a tape measure was used when aligning the magnets.(Fig.11)

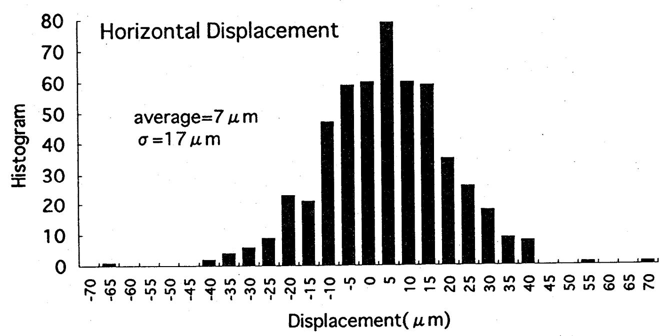

Fig.9. Horizontal displacements of multipole magnets.

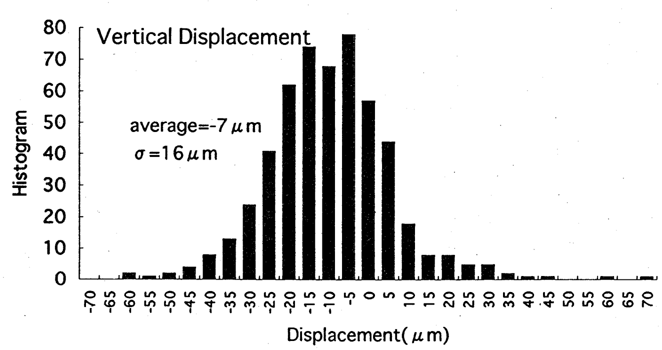

Fig.10. Vertical displacements of multipole magnets.

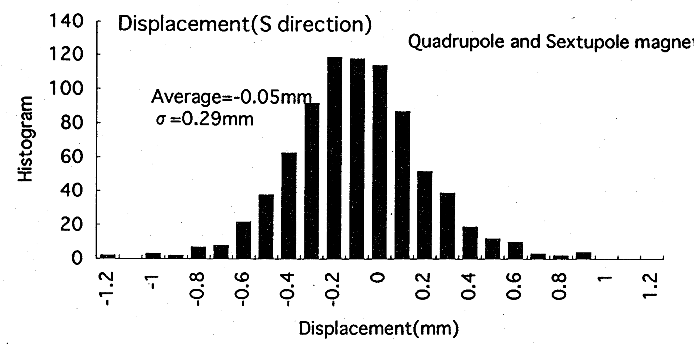

Fig.11. S-directional displacements of multipole magnets.

4.1 Thermal Deformation

The girder and magnets expand as temperature. There are many cables under the girder. Fig.12 shows the changes of the vertical displacements by current flow. The reference points are both end magnets in a girder. This figure shows the middle magnets rise up about 10~30 μm at 1.7m level.

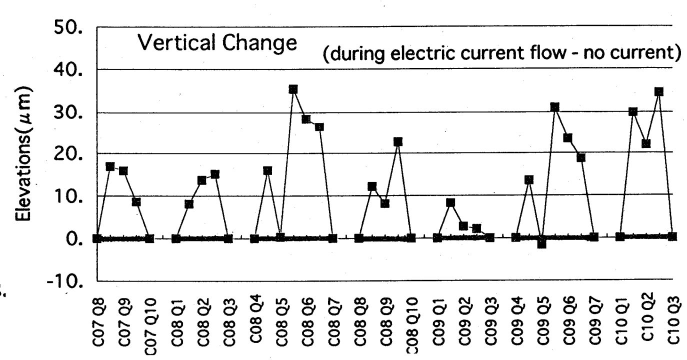

Fig.12. Thermal deformation in a girder.

5. Concluding Remark

It is not desirable that there is some space under the floor.

The obvious floor level changes in the improved foundation area (about 30%) cannot be detected now.

It is most important to survey and adjust the girder under the same temperature, if possible operating temperature.

It is not good that the vacuum force pulls the magnet.

The thermal effect especially by current flow is important for the alignment in a girder.