Magnet Horizontal Survey before the Storage Ring Commissioning

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1. Introduction

Installation of the magnets for the SPring-8 storage ring started from May, 1995 and completed in March, 1996. Commissioning of the ring is scheduled in March, 1997. After alignment the magnets experienced many things that may displace their positions. Before commissioning surveys were done to give final magnet positions and take last adjustments. Circumference of the ring was also measured.

2. Circumference of the storage ring

It is comparatively difficult to control global positions for the magnets of the SPring-8 storage ring, because the ring is surrounding the hill of Mihara-Kuriyama which prevents us to measure the ring's diameter.

Circumference of the storage ring is 1436 meters with 48 magnet cells. Each cell is about 30 meter in length. In the procedures of monument survey and magnet survey & alignment, the circumference of ring is ensured mainly by the network surveying. By measuring the distances between monuments with the mekometer ME5000, we estimated the circumference has an error about 1.76 ±2 mm. For the storage ring commissioning, geometric circumference was measured precisely in July, 1996.

The Smart 310 was used to measure the circumference. It was compared and calibrated with the HP 5527A laser interferometer beforehand. It is recognized that by careful calibration the Smart 310 has a measurement precision about 1 μm for 10 meters, and <4 μm for 20 meters. Its precision gets worse as measuring distance increases, about 20 mm in 30 meters. In actual measurement, the Smart 310 was set at the middle of each cell and measures the cell chord. Sum of the 48 chords compares with that of ideal length gives circumference error for the ring.

As the result, the circumference is measured 1.9 mm longer than ideal one. For the 1436-meter ring, the circumference error is merely 1.3 ppm (Fig.1).

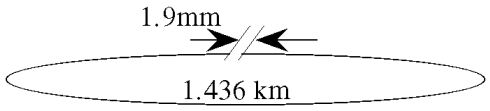


Fig.1 Circumference error for the ring.

Momentum compaction factor of the ring is 1.46×10^{-4}, therefore for the momentum change is 1%:

$$\frac{\Delta p}{p} = \frac{1}{\alpha} \times \frac{\Delta l}{l} = \frac{1.9}{1.46 \times 10^{-4} \times 1436 \times 10^{3}} = 1\%$$

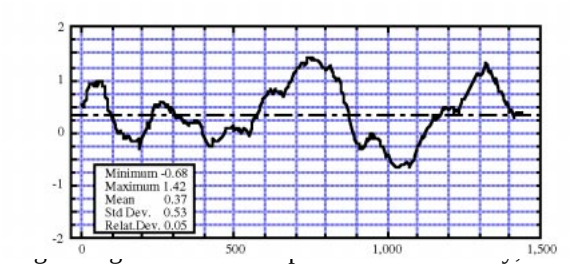
3. Displacements of magnet units

Installation of the storage ring magnets started from May, 1995 when four cell magnets of the first phase were installed. Total magnet installation was ended by March, 1996 and we got a satisfied alignment result[1]. After alignment, the magnets had experienced many things that may displace their positions: 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, about 5 degree change on average. Therefore in October, 1996 and January, 1997 the ring was surveyed twice.

Transverse deviation between adjacent units for the magnet units was 60 mm in the survey of October, 1996. Comparing to the results that before vacuum chamber installation (40 mm), although relative precision was getting worse, it was achieved with vacuum system on. So, deterioration was small owing to excellent design of the girders as well as the magnets. After this survey 27 out of 144 girders that displace over 0.1 mm transversely were adjusted. A number of bending magnets were also re-adjusted. These bending magnets' positions on beam direction are affected remarkably by the vacuum force which comes from the bellows. Displacement of bending

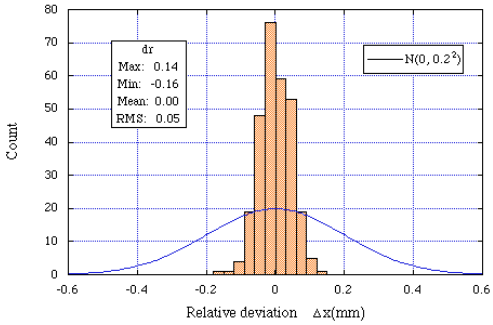
magnet is kept below 0.5 mm in beam direction.

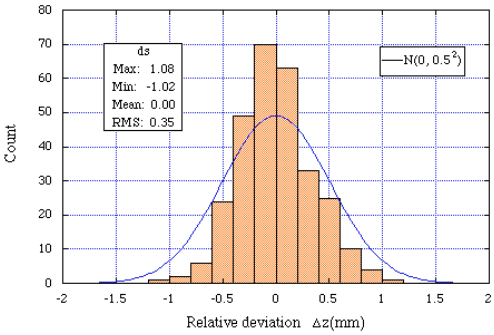
Survey results for 96's are omitted. Figure 2 gives the result for 97's, the survey just before the storage ring commissioning. This is obtained by a distance and angle combined survey. Angular measurement between units is necessary to reduce transverse displacement as a whole, but it does not affects relative positions between units 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.



7.

The relative precision achieved in beam transverse direction is notable, which is 0.05 mm comparing to the tolerance of 0.2 mm (Fig.3). Deviation in beam direction is 0.35 mm between the magnet units(Fig.4). It is also within the tolerance.





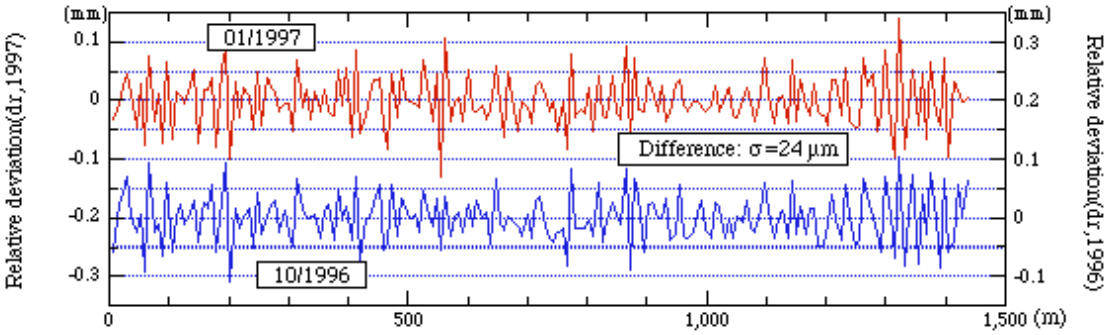


Fig.5 Two round of magnet surveys of 97's and 96's. Difference for the relative deviation is 24 mm.

Figure 5 gives a comparison between the two round magnet surveys of 97's and 96's. Transverse deviation of each measuring point with respect to adjacent points is compared, except for the magnet units that had been moved after 96's survey. Difference between them is such small as 24 mm. That means the survey gives a precision better than 20 mm for the relative position between measuring points.

Reference

[1] C.Zhang and S.Matsui, annual report 1995, SPring-8, 117-118.