Magnet Level Survey in the SPring-8 Synchrotron

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1. Introduction

The SPring-8 synchrotron accepts an electron beam with an energy of 1 GeV from the SPring-8 linac. The beam is accelerated up to 8 GeV and then ejected to stack into the SPring-8 storage ring [1]. The synchrotron consists of a FODO lattice of 40 cells and its circumference is 396.124 m. There are 64 bending, 80 quadrupole, 60 sextupole, and 80 correction magnets.

Horizontal and vertical closed orbit distortions (CODs) are induced mainly by alignment errors of the quadrupole magnets. The alignment tolerances of the magnets in the radial vertical and longitudinal directions were designed to be ±0.2 mm. A SMART310 system, a theodolite and a Wild N3 level were used for the alignment [2]. In January 1996, the alignment was finished. After the first COD-measurement, we confirmed that the alignment of the magnets was achieved within the expected accuracy [3]. The beam position at the injection point to storage ring changes when the COD changes. To observe the elevation changes of the quadrupole magnets for three years, the levels were measured in July 1999.

2. Magnet Level Survey

In the synchrotron, 40 focus- and 40 defocus-quadrupole magnets were installed alternately (fig.1). Using a Wild N3 level, the relative height difference between the two quadrupole magnets was measured. A spherical ball target with a patterned glass plate was put on the fiducial point of the magnets.

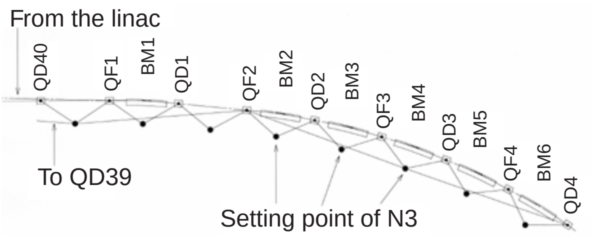

Fig. 1. Arrangement of the quadrupole magnets near the injection point from the linac is shown. Solid lines indicate network of the level survey.

The network of the level survey is also shown in Fig. 1. The N3 was placed at a point equidistant from the two targets. In short-range measurement, the level difference between two neighboring magnets was measured. Long-range measurement was carried out every five magnets to compare with the short-range measurement. The distances from N3 to the target in the short- and long-range measurements were about 3.0 m and 12.6 m, respectively. The fiducial point of the QF1 magnet was selected as a reference point. Based on the measurement, absolute displacements in the height direction were obtained with the least-squares fit for all magnets.

The pitch and roll of the quadrupole magnets were also measured using a NIVEL. The NIVEL is a tilt meter with a resolution of 1 μrad.

3. Results and Discussion

The accumulated error in the short-range measurements for eighty times was estimated to be 140 μm. The difference in the measured level between the short- and long-range measurements was less than 40 μm.

The absolute displacements of the quadrupole magnets are shown in Fig. 2. The solid line indicates the value of the present work. The magnet levels were surveyed three times (December 1995, January 1996 and March 1996). These data are also shown in Fig. 2. The maximum elevation change over three years was estimated to be 0.8 mm. This change was greater than the above mentioned in the error of survey. The pitch and roll of the quadrupole magnets are shown in Fig. 3. Change in these values were comparable with the designed one (0.2 mrad).

Vertical COD is generated mainly by the displacements of the defocus-quadrupole magnets. Based on the measured level of the defocus-quadrupole magnets, vertical COD was simulated by code "RACETRACK" (Fig. 4). Using eighty beam-position-monitors (BPMs) [4], vertical COD was measured at the energy of 8 GeV in March 1999. All correction magnets were turned off to measure COD without correction. The measured COD are also shown in Fig. 4. The calculated COD was consistent with the measured one.

4. Conclusion

The elevation changes of the quadrupole magnets were estimated over three years. We are planning to take continuous measurements of the elevation changes in the quadrupole magnets using a hydrostatic leveling system.

References

[1] H. Suzuki *et al.*, Rev. Sci. Instrum., **66** (1995) 1964.

[2] K. Fukami *et al.*, Proceedings of the 10th Symposium on Accelerator Science and Technology, 1995, Hitachinaka (1995) 103.

[3] K. Fukami *et al.*, Proceedings of Fifth International Workshop on Accelerator Alignment, IWAA97, 1977, ANL.

[4] T. Aoki *et al.*, Proceedings of SRI'95, Rev. Sci. Instrum. **67** (1996) 3367.

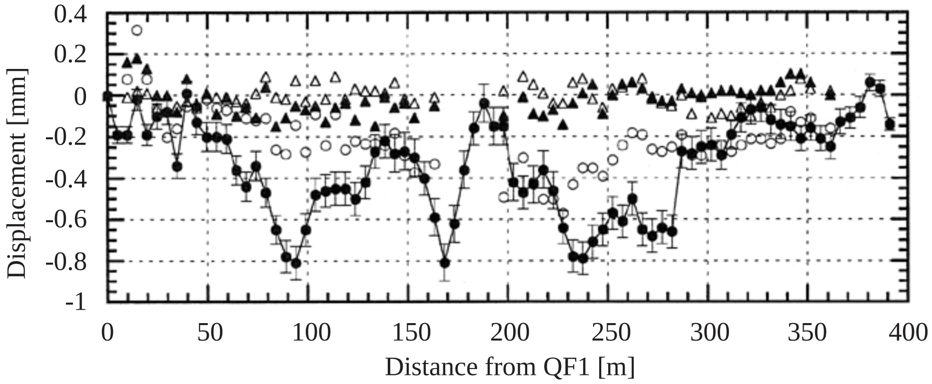

Fig. 2. Absolute displacements of the quadrupole magnets are shown. Closed circle and solid line indicates the measured value of the present work. Error bar indicates an error of the least-squares fit. Open triangle, closed triangle and open circle indicate measured values in December 1995, January 1996 and March 1996, respectively.

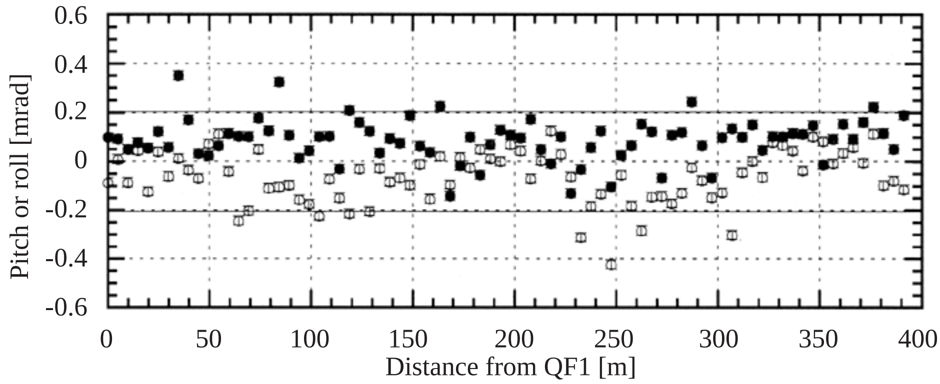

Fig. 3. Pitch and roll of the quadrupole magnets are shown. Closed and open circles indicate the pitch and roll of the magnets, respectively. Error bars indicate the standard deviations of 13 times measurement on the same magnet. Solid lines indicate the designed value.

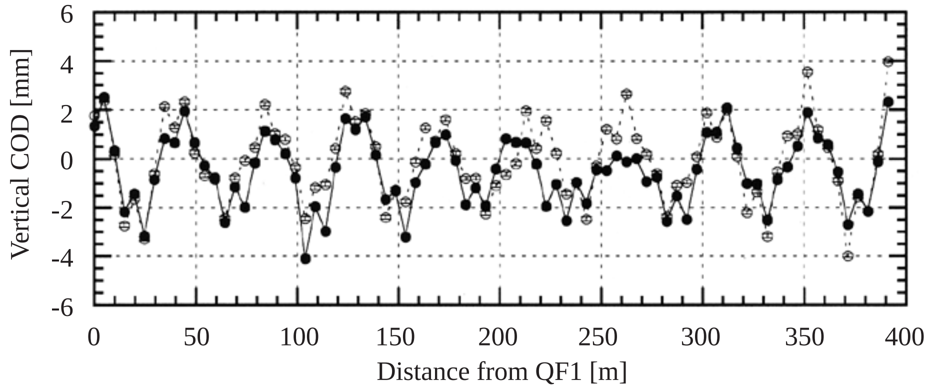

Fig. 4. Vertical CODs are shown without correction. Open circle and dotted line indicate measured COD using BPMs. Closed circle and solid line indicate calculated COD based on the measured level of defocus-quadrupole magnets. Error bar indicates the standard deviations of 10 times measurement on the same condition.