Summary of Field Measurement for SPring-8 Storage Ring Magnets

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1. Introduction

The SPring-8 storage ring has 88 dipoles, 480 quadrupoles and 336 sextupoles, which had been completed and delivered by May 1995. Their parameters are listed in Table 1. The quadrupoles and sextupoles have six and three types, respectively, whose cross-sectional shape and/or length are different.

All the magnets were made field measurements one by one. It took 30 days to make the measurement of the dipoles during the period from July 1993 to February 1995. On the other hand, for the quadrupoles and sextupoles it took 170 days from August 1994 to June 1995.

The measurements of the dipoles were done with a long flip coil and the quadrupoles and sextupoles with a rotating coil. The measurement apparatus and method are described in ref. [1][2].

2. Measurement Results

2-1 Magnetic Field Strength

Measurement results for integrated magnetic field strengths are also shown in Table 1. Imax denotes the maximum current which can be excited with the actual power supply. The magnetic strength and dispersion is the average and rms of the measured value for each magnet at the maximum excitation level, respectively. Since the tolerances for the dispersion of the magnetic strength are 5×10^{-4} for the dipoles and quadrupoles, 1×10^{-3} for the sextupoles, it is found that two types of the quadrupoles and one type of sextupoles are slightly over the tolerances and all other types within the tolerances.

2-2 Measurement of the Field Center Position for the Quadrupoles and Sextupoles

Each quadrupole and sextupole has two fiducial points on upper yokes for its positioning in the ring tunnel. These points consist of planes with holes machined at a fixed position just above the mechanical center of the magnetic poles. Since, however, their position accuracy in manufacturing was over 20 or 30 μm which are necessary to obtain the requirement for alignment, the position of the fiducial points was remeasured when the field measurements were done. The measurement method and tools are described in ref. [3][4].

Figures 1 show histograms of position deviations of the fiducial points measured for each magnet. The averages of the deviations correspond to the offset due to the measuring system and/or systematic errors in manufacturing magnet fiducial points. Because, however, these offset errors are small and lead to only the same position deviations for all magnets, it does not influence the accuracy of magnet positioning.

On the other hand, the measuring reproducibility in the rotating coil system was significant because each magnet is aligned with the measured values of the position of the fiducial points. The reproducibility was estimated to be about 10 μm for horizontal and vertical directions from repeat measurements and an analysis of error sources [3]. Therefore, it is found that this measurement system satisfy the requirement for positioning accuracy for each magnet, namely 50 μm in horizontal and vertical directions.

2-3 Movement of the Magnetic Center with Excitation Level

The position of the magnetic center was measured at several current levels for each quadrupole and sextupole. Figures 2 show histograms of the movement of the magnetic center between 200 and

Table 1. Parameters and field measurement results of the storage ring magnets

		B	Qa	Qb	Qc	Qd	Qe	Qf	Sa	Sb	Sc
Number		88	96	96	144	48	48	48	92	196	48
Core Length	m	2.72	0.31	0.37	0.47	0.93	0.47	0.37	0.27	0.26	0.47
Gap / Bore Radius	m	0.0638	0.85	0.85	0.85	0.85	0.85	0.85	0.92	0.92	0.92
Imax	A	1270	558	521	562	569	549	569	300	300	300
Turns / Pole		14	24	24	24	24	24	24	19	19	19
Magnetic Strength*	Tm T T/m	1.962	6.100	6.907	9.071	17.60	8.984	17.69	131	128	221
Dispersion*	10^{-4}	3.2	4.8	5.3	6.0	4.4	2.7	4.6	10.7	8.6	4.9
Ampere Factor*		1.005	1.094	1.053	1.072	1.052	1.057	1.047	1.029	1.022	1.017

*) measured values

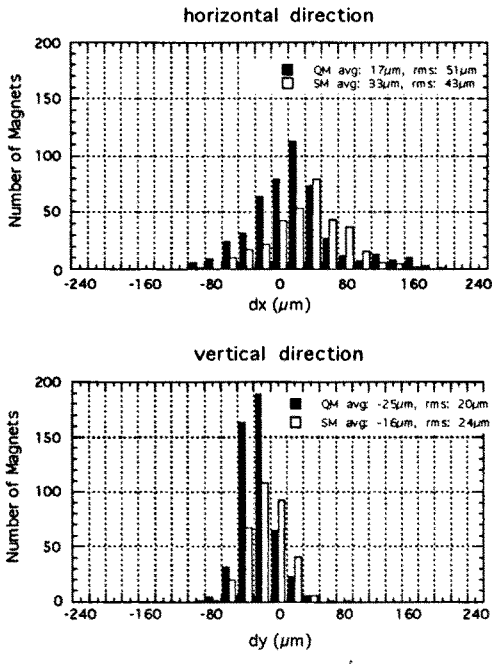

Fig. 1. Histograms of position deviation of fiducial points for each magnet.

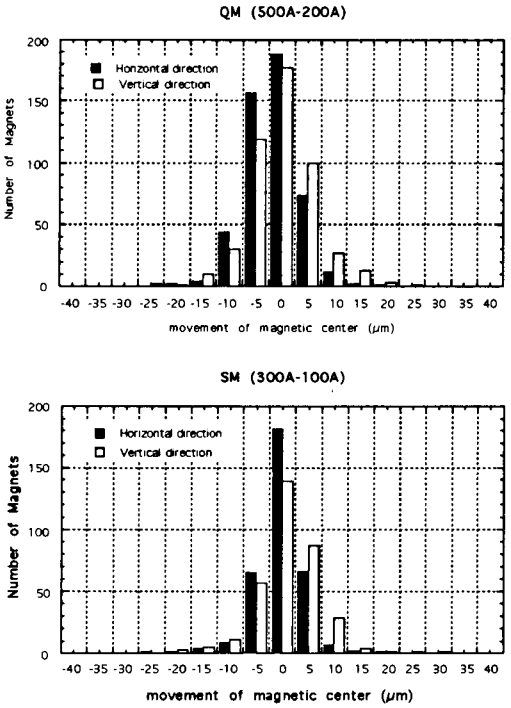

Fig. 2. Histograms of movement of magnetic center in two current levels.

500 A for quadrupoles, 100 and 300 A for sextupoles. The measurement accuracy is about two μm same as the order of the stability of the measurement. One of the considerable causes is that magnetic poles are moved mechanically due to the magnetic force because of imperfection in magnet fabrication, which can be estimated from that the distribution of the histograms is homogeneous in direction.

3. Summary

We finished the field measurements for all the dipoles, quadrupoles and sextupoles for the storage ring. Their measured field performances satisfied the required specifications. At present, the magnet positioning in the tunnel is being done on basis of the position of the magnet fiducial points measured for each quadrupole and sextupole in the magnetic field measurements.

References

[1] J. Ohnishi et al., SPring-8Annu. Rep. 1994, p. 138 (1995).
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[3] J. Ohnishi et al., Proc. 10th Symp. on Accelerator Science and Technology, Hitachinaka, Japan, p. 203 (1995).
[4] Y. Chida et al., Proc. 4th Int. Workshop on Accelerator Alignment, Tsukuba, Japan, p. 194 (1995).