Calibration of the Storage Ring Magnets and their Power Supplies

Jun-ichi OHNISHI and Hideki TAKEBE

SPring-8, Kamigori, Ako-gun, Hyogo 678-12, Japan

1. Introduction

The SPring-8 storage ring consists of 88 dipoles, 480 quadrupoles and 336 sextupoles. The quadrupoles and sextupoles have six types (Qa, Qb, Qc, Qd, Qe, Qf) and three types (Sa, Sb, Sc) whose lengths and/or yoke configurations are different[1]. Further, these quadrupoles and sextupoles are classified into ten and seven families and excited by an individual power supply[1]. This report describes the method and results of the calibration of these magnets and their power supplies.

2. Measurement of Absolute Magnetic Field Strength

2-1 Dipole Magnet

For all dipole magnets, integrated magnetic strengths were measured with a long flip coil[2]. However, absolute values of the integrated field were not obtained because it was difficult to measure area of the coil precisely. Therefore we made mapping measurement with a hall probe for only two dipoles. After the hall probe was calibrated with NMR probes, the mapping measurements were done using a three dimensional moving stage. A mapped area was 3.57m x 80 mm on a median plane and measuring intervals were 10 mm and 5 mm in longitudinal and transverse directions. Figure 1 shows the transverse distributions of the integrated field along the magnet and beam orbit. It is found that beams suffer focusing force though the magnet is a rectangular type. The reason is because the entrance and exit positions of the beams in the dipoles are not located in the center of magnet poles.

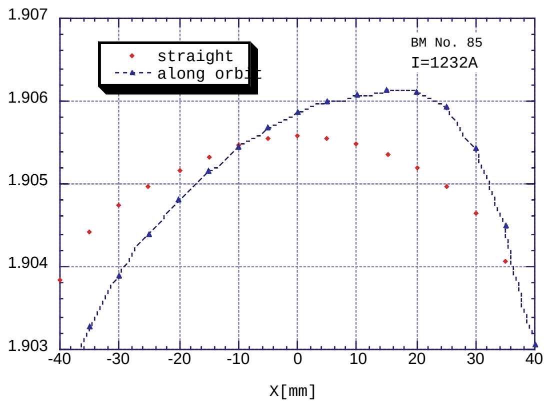

Fig. 1. Transverse distributions of the integrated dipole field along the magnet and beam orbit.

2-2 Quadrupoles and Sextupoles

For all the quadrupoles, magnetic field measurements were made with a rotating coil[2]. However, it was not clear whether the measured magnetic field strengths can be compared for different types of magnets. If, for example, a width of the measuring coil are not constant along the longitudinal direction, measured values are not scaled for the magnets with different lengths. In order to check a degree of the scaling, we made mapping measurements with a small twin search coil[3]. Figure 2 shows ratios of the integrated quadrupole field strengths measured with the rotating coil and calculated from measured values with the search coil. The measurements were done for all types of the quadrupoles at several current levels. It is found that a degree of the rotating coil measurement was about 5 x 10-4 for different type of magnets except at low current levels where measuring accuracy of the search coils is deteriorated due to small output voltage.

Further, to measure absolute values of magnetic field strengths of the quadrupoles and sextupoles, one quadrupole of Qa type and one sextupole of Sa type were made measurement by mapping with a hall probe. A mapped area was 850 mm and 20 mm in longitudinal and transverse directions for the quadrupole and the intervals were 10 mm and 2 mm, respectively. For the sextupole, 750 mm and 40 mm in the intervals of 10 mm and 4 mm. Measurement results are shown in Tables 1 and 2.

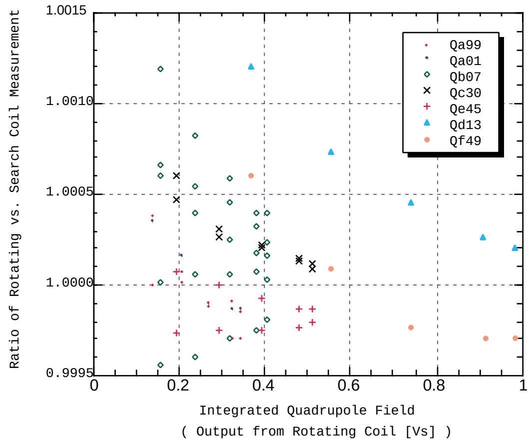

Fig. 2. The normalized ratios of integrated quadrupole fields measured with a rotating coil and a search coil.

Table 1. Integrated magnetic strengths for the quadrupole Qa01

Current[A]	Hall [T]	Coil[Vs]*	ratio**
200	2.3891	0.13627	1
300	3.5763	0.20396	1.0001
400	4.7342	0.26989	1.0005
500	5.7029	0.32514	1.0005
550	6.0475	0.34476	1.0005

*) Output from the rotating coil
**) Normalized at 200A

Table 2. Integrated magnetic strengths for the sextupole Sa01

Current[A]	Hall [T/m]	Coil[Vs]*	ratio**
100	22.506	0.023110	1
200	45.022	0.046291	0.9987
300	65.556	0.067273	1.0008

*) Output from the rotating coil
**) Normalized at 100A

Consequently, the absolute field strengths were to be obtained for all types of the quadrupoles and sextupoles because the integrated field strengths measured with the rotating coil are scaled as described formerly.

3. Measurement of Excitation Curves

The excitation curves were measured with the long flip coil for the dipole and with the rotating coil for six types of the quadrupoles and three types of the sextupoles. The measurements were made for only one magnet for each type. Figure 3 shows the excitation curves of six types of the quadrupoles. Magnetic strength indicated in the ordinate is converted from the calibration results mentioned above. In the real operation, five dimensional polynomial equations fitted from these excitation curves are used in conversion from magnetic strength to current. In case of quadrupoles, two equations for low and high current levels are required for each type. The deviation of the fit equations are within 2x10^{-4} at measuring points.

4. Calibration of Excitation Current

The dipoles, quadrupoles and sextupoles are powered by using one, ten and seven power supplies, respectively. On the other hand, two power supplies were used for the magnetic filed measurements. These total twenty power supplies were calibrated with four DCCTs produced by HOLEC. The four DCCTs were not differentiated because deviation of readings were smaller than 50 ppm. Figure 4 shows the differences between set current values and calibrated ones for the ten quadrupole power supplies. Linear equations fitted from these calibration curves are used for real operation of the power supplies.

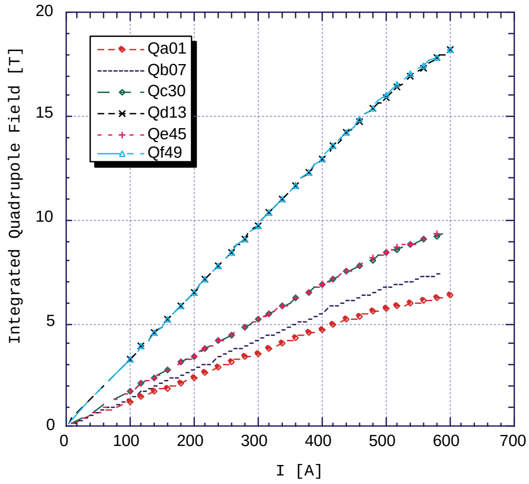

Fig. 3. Excitation curves for six types of the quadrupoles.

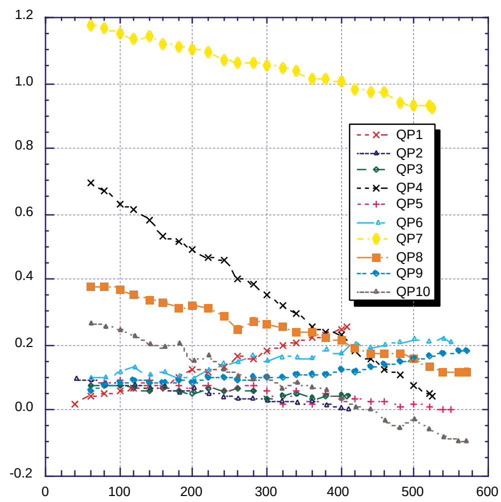

Fig. 4. Calibration results on ten power supplies for the quadrupoles.

5. Conclusion

The calibration results described in this paper were reflected in the control software of the magnet power supplies. To be concrete, a function which convert magnetic strengths to currents was written down in C language. Compensation of each power supply are made by the software on VMEs controlling it directly.

References

[1] SPring-8 Project Team, SPring-8 Project Part I, Facility Design (1991).[Revised].
[2] J. Ohnishi et al., IEEE Trans. Magnetics, **32**, 3069(1996).
[3] J. Ohnishi et al., IEEE Trans. Magnetics, **28**, 546(1992).