Measurement of Magnetic Field Distribution of the Dipole, Quadrupole, Sextupole Magnets for the SPring-8 Synchrotron

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1.Introduction

The good field region of ±30 mm is necessary for all dipole, quadrupole and sextupole magnets since the closed orbit distortion (C.O.D) is estimated as±30 mm for SPring-8 synchrotron. Therefore, the horizontal magnetic field distribution was measured for the range of ± 40 mm from the magnetic center for the preceding magnets of the dipole, quadrupole and sextupole magnets. In order to obtain the reappearance of magnetic field, it is demanded that the hysteresis of the magnets are small.

2. Feature of Magnets

The magnets of the synchrotron are 64 dipole magnets, 80 quadrupole magnets, 60 sextupole magnets and 80 correction magnets. The core of each magnet is stacked with 0.5 mm thick, silicon steel sheets. The dipole magnet has a C type core and assembled by lamination stacking; this is curved with parallel end plates. The pole width is 140 mm and there are lateral shims 7.5 mm wide and 1 mm height. A cross sectional view of dipole magnet is shown in Fig.1.

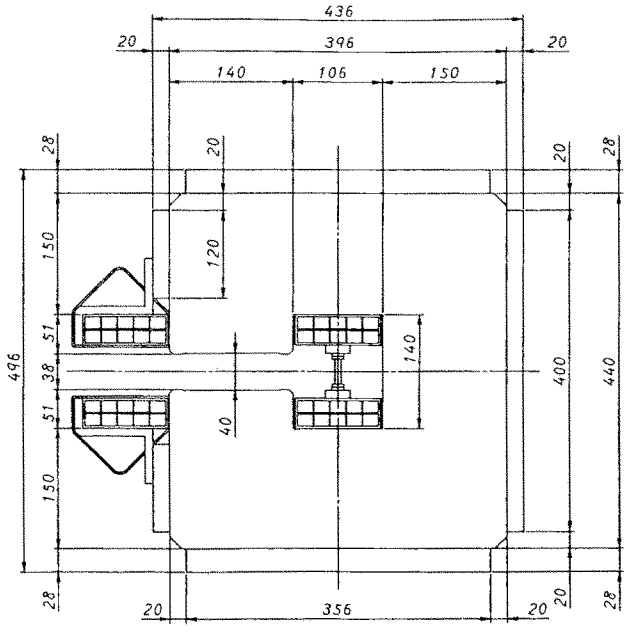

Fig.1. A cross sectional view of dipole magnet

The pole length is 2870 mm. The maximum field strength of dipole magnets is 0.9 T. The Bohr radius and the length of the quadrupole are 70 mm and 0.57 m. And those of sextupole are 100 mm and 0.15 m. Quadrupole and sextupole magnets are constructed with two-piece core-structure. The maximum field strength of those magnets are 15 T/m and 200 T/m2, respectively.

3.Measurement of Magnetic Field

3-1 For a dipole magnet

Excitation, BL product and magnetic field distribution were measured. To estimate the hysteresis of dipole magnets, the excitation were measured by means of a NMR probe at the center of the pole. This measurement have been finished for 23 magnets. It was verified that the magnetic field was nearly in proportion to excitation current within 0.2 % of linearity. The BL products were measured with a longflip-coil. This measurement have been finished for 23 magnets. It was confirmed that the effective length of the magnets were 2930 mm and variation of the BL products within 5 x 10-4 at 1500 A of excitation current which corresponds to 8 GeV. Magnetic field distributions were measured with a hall-probe for 3 magnets (Fig.2). The transverse field distribution of the magnet center and that of the integrated strength of a beam path were obtained. These are shown in Fig.3 and 4. The variation of the former and the latter were less than 5 x 10-4 and 1 x 10-3 in the range of ±30 mm, respectively.

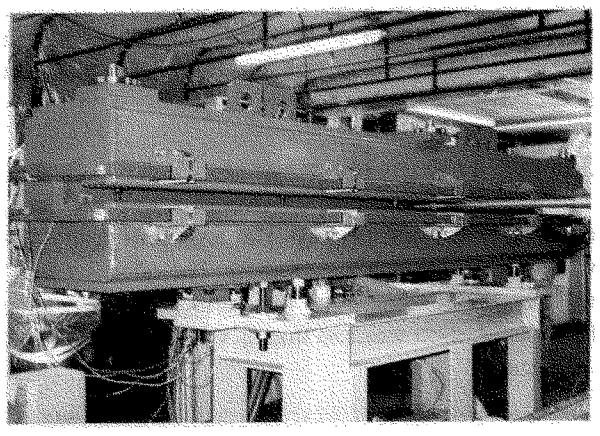

Fig.2. Photograph of the Dipole Magnet (in measuring the magnetic field-distribution with a hall-probe)

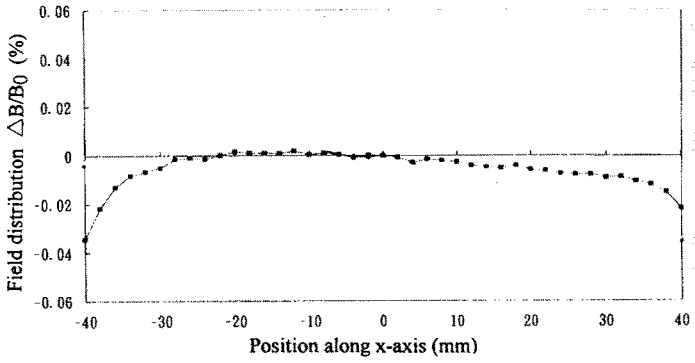

Fig.3. Radial field distribution in the magnet center. (Normalized by the central value.)

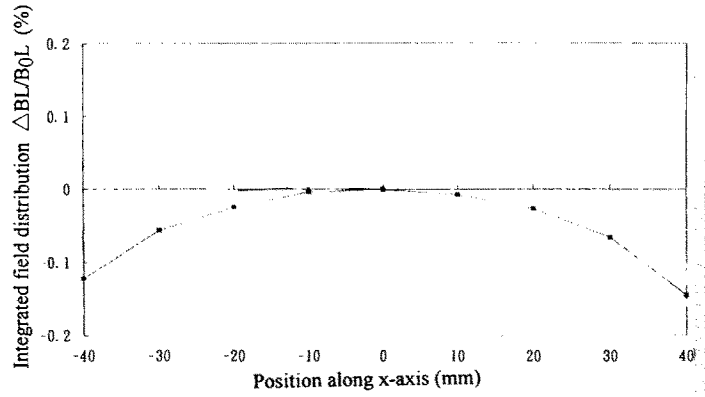

Fig.4. The distribution of the integrated magnetic field. (Normalized by the central value.)

3-2 For a quadrupole magnet

Excitation curve, multipole component, effective lengths and magnetic gradient distribution were measured (Fig.5). The excitation was measured by means of the twin-coil. The multipole component was measured with the harmonic-coil. This measurement have been finished for 1 magnet. The multipole component was approximately 0.2 %. The effective length was measured with the twin-coil and the harmonic-coil. This measurement have been finished for 1 magnet. The effective length was obtained as 608 mm. The magnetic gradient distribution was measured with the twin-coil for 1 magnet. The variation of the radial field distribution was less than 2 x 10-3 in the range of ±30 mm.

3-3 For a sextupole magnet

Same measurements were performed as a quadrupole magnet (Fig.6). The multipole component was approximately 0.5 ~ 2.5 %. The effective length was obtained as 182 mm. The variations of the radial field distribution was less than 2 x 10-3 in the range of ±30 mm.

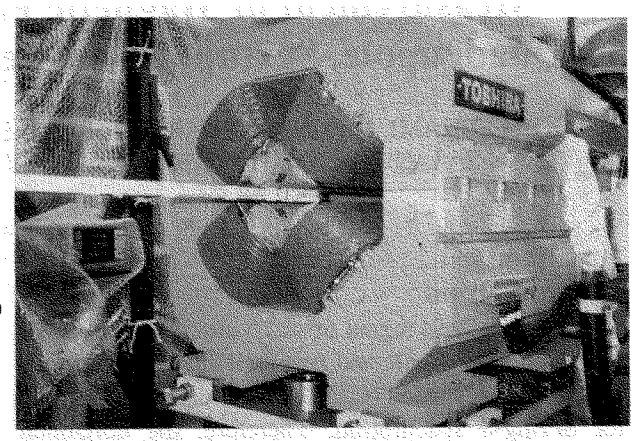

Fig.5. Photograph of the Quadrupole Magnet (in measuring the magnetic field-distribution with a twin-coil)

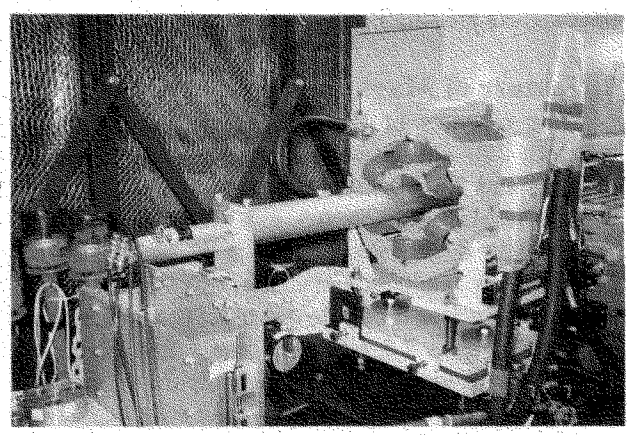

Fig.6. Photograph of the Sextupole Magnet (in measuring the multipole component with a harmonic-coil)

4.Conclusion

It was confirmed that the mark quality was satisfied for all preceding magnets. Based on a know-how of the preceding magnets, all magnets are now in mass production.