MAGNETIC MEASUREMENTS OF THE SSRF STORAGE RING MAGNETS

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Abstract

The SSRF storage ring consists of 40 bending magnets with a maximum field of 1.2726 T, 200 quadrupoles divided in three families with a maximum gradient of 20 T/m, 140 sextupoles with a maximum second order differential of 460 T/m^2. The production of all the magnets is now finished. For the dipoles a long coil system has been used to measure the magnetic field while for the quadrupoles and sextupoles a rotating coil system has been used to determine the magnitude of the high order multipoles. In this paper the analysis of these data is discussed and results for measured magnets are presented.

INTRODUCTION

The magnetic system of the SSRF storage ring [1] [2] is summarised in table 1.

Table 1: The Magnetic System of the SSRF Storage Ring

Magnet type	Name	Number	Max. magn
Bending	B1440	40	1.2726 T
Quadrupole	Q260	40	20 T/m
Quadrupole	Q320	120	20 T/m
Quadrupole	Q580	80	20 T/m
Sextupole	S200	80	460 T/m^2
Sextupole	S240	60	460 T/m^2

For each type of magnet a prototype was produced to test the expected magnetic performance. The results [3] indicated a performance comparable to what had been expected; therefore the magnets were produced with only minor modification from the prototypes.

THE MAGNETIC MEASUREMENTS

The SSRF storage ring bending magnets and quadrupoles were built and measured at IHEP. For the dipoles a long coil system has been used to measure the transverse distribution of the field integral at the nominal current of the magnet. For the quadrupoles an IHEP rotating coil system has been used to determine the magnitude of the high order multipoles. The SSRF storage ring sextupoles and correctors were built and measured at SINAP. For the sextupoles a SINAP rotating coil system has been used to determine the magnitude of the high order multipoles[4]. For the correctors a SINAP stretch-wire magnet measurements system has been used to measure the distribution of the integral field error.

MEASUREMENT RESULTS FOR PRODUCTION MAGNETS

Bending Magnets

Figure 1 shows a typical field quality in the transversal direction at different currents.

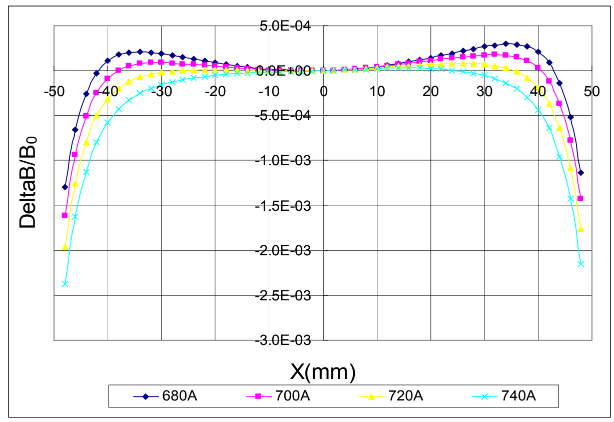

Figure 1: Transversal field quality for a bending magnet

An alternate way to represent the field quality of the magnets is to give the harmonic decomposition of the field. Table 2 summarizes the integral harmonics in the magnets at the central position of the measuring coil at 3.5 GeV excitation. Figure 2 shows the relative difference from the mean integrated field for the magnets that have been measured at nominal current. The relative difference is below$\pm$ 1×10^{-3}.

Table 2: Integral Harmonics at 54 mm (3.5 GeV)

Harmonic [Bn/B1]	Std. Dev.	Max.
B2/B1	4.47E-05	1.3E-04
B3/B1	7.91E-05	1.2E-04
B4/B1	1.44E-05	2.6E-05
B5/B1	6.98E-05	7.7E-05
B6/B1	1.89E-05	2.7E-05

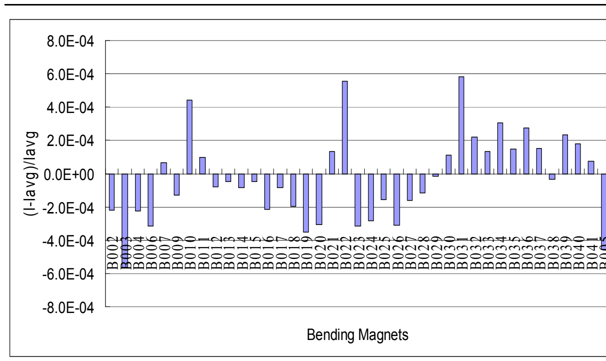

Figure 2: Relative deviation from the mean field integral for the bending magnets at 720 A

Quadrupole Magnets

The SSRF quadrupoles with 36 mm bore radius have three different lengths, 26cm (Q260), 32cm (Q320) and 58cm (Q580). The integrated multipole error distribution and the offset of magnetic centre were measured at twenty-one currents on all quadrupoles. The max values of the relative multipole errors of Q580 at 242A are listed in Table 3. Their standard deviations are less than 3×10^{-4}. Figure 3 shows the field Error distribution of Q260 at a typical magnet.

Table 3: Q580 Integral Harmonics at R=26 mm

Harmonic [Bn/B2]	Std. Dev.	Max.
B3/B2	2.02E-04	3.07E-04
B4/B2	1.37E-04	2.85E-04
B5/B2	1.66E-05	3.77E-05
B6/B2	4.80E-05	7.84E-05
B10/B2	5.70E-05	6.18E-05
B14/B2	9.63E-06	1.04E-05

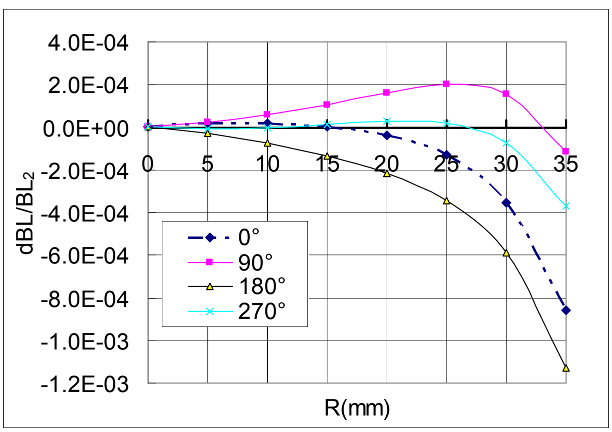

Figure 3: The field Error distribution of the typical Q260 magnet (3.5 GeV operations)

Q320 excitation curve measured by the Integral coils is shown in Fig. 4. The maximum field gradient of 20 T/m is achieved with a current of 242 A. Figure 5 shows Q320 magnet family transfer functions.

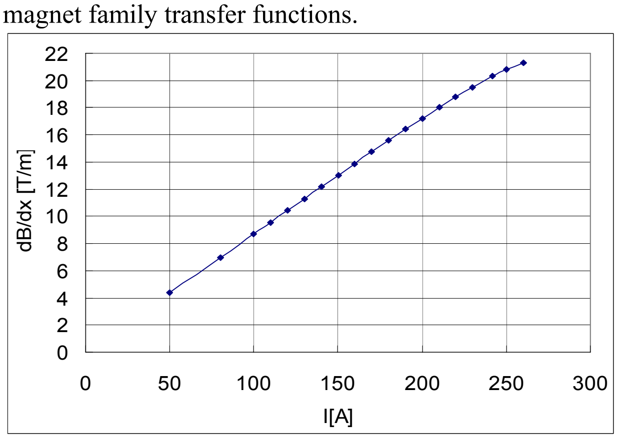

Figure 4: Excitation curve of the typical Q320 magnet

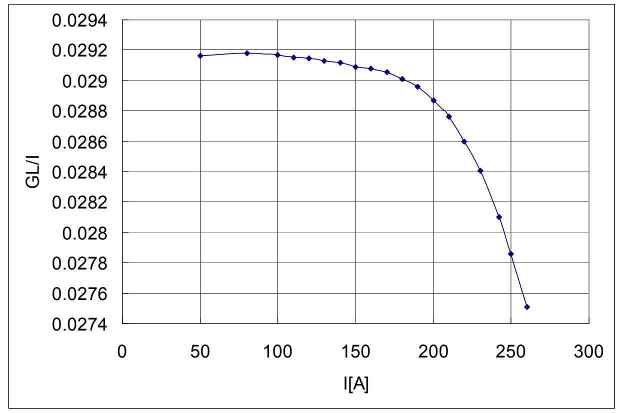

Figure 5: Q320 magnet family transfer functions

Figure 6 shows that relative difference between the measured integrated gradient and the reference integrated gradient. For the 40 Q580- quadrupoles, ⊿GL/GL stays below 3×10^{-3}. For the quadrupoles Q260 and Q320 the same measurements have been performed.

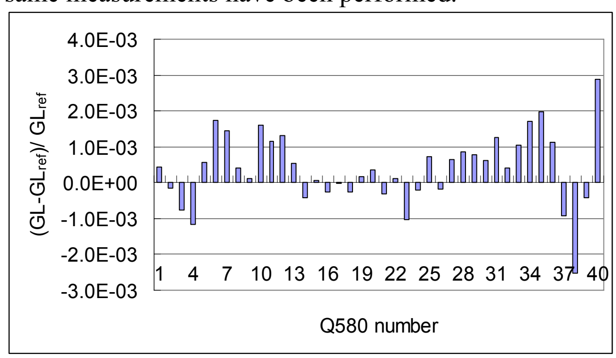

Figure 6: Relative deviation from the reference integrated gradient for the Q580 quadrupoles at 242 A

Sextupole Magnets

The SSRF storage ring sextupole magnets with 44 mm bore radius have two different lengths, 20 cm (S200) and 24 cm (S240). These sextupole magnets operate at a field strength of up to 460 T/m^2 , The max values of the relative multipole errors of sextupoles at 255A are listed in Table 4. Their standard deviations are less than 6×10^{-4}.

Table 4: S240 Integral Harmonics at R=26 mm

Harmonic [Bn/B3]	Std. Dev.	Max.
B4/B3	3.51E-04	8.69E-04
B5/B3	2.52E-04	4.33E-04
B6/B3	1.25E-04	2.80E-04
B9/B3	5.47E-04	5.58E-04
B15/B3	1.19E-04	1.22E-04
B21/B3	2.82E-06	2.96E-06

Figure 7 shows the field Error distribution of S200 at a typical magnet.

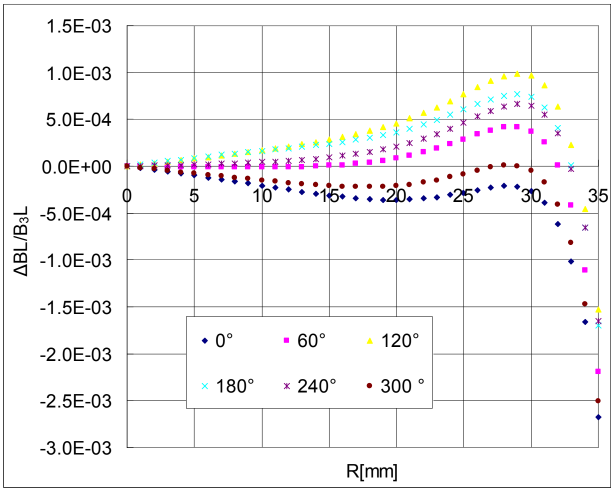

Figure 7: The field Error distribution of the typical S200 magnet (3.5 GeV operations)

S200 excitation curve measured by the Integral coils is shown in Fig. 8. The maximum Field Strength of 460 T/m^2 is achieved with a current of 255 A. Figure 9 shows S200 magnet family transfer functions.

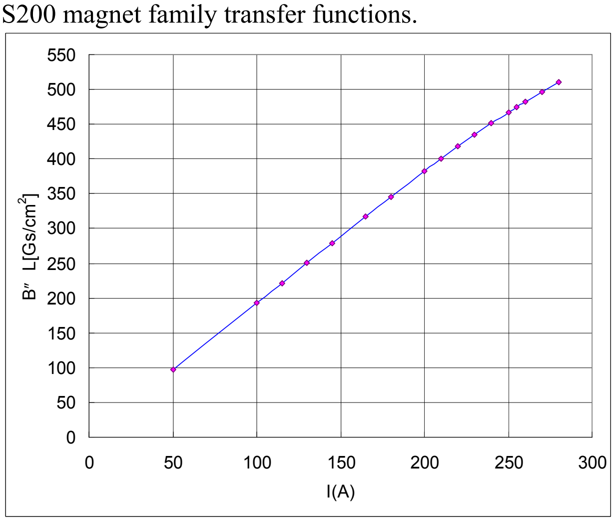

Figure 8: Excitation curve of the typical S200 magnet

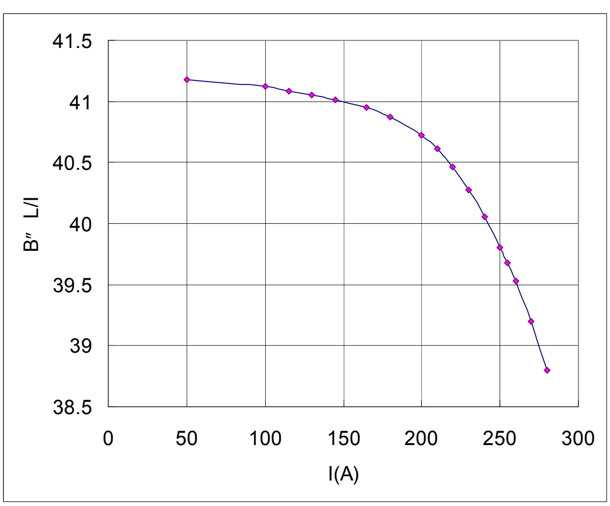

Figure 9: Variation of the ratio of integrated sextupole strength to current (B"L/I) with current I

Figure 10 shows the relative deviation from the reference integrated sextupolar component for the S240 sextupoles at 255A.

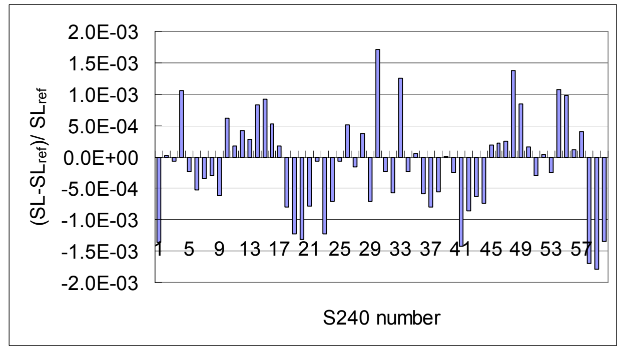

Figure 10: Relative deviation from the reference integrated sextupolar component for the S240 sextupoles at 255A

SUMMARY

The measurements of the SSRF magnets are well advanced. The 240 quadrupoles measured are within specifications. The relative spread in integrated quadrupole strength amongst the different families is below 3×10^{-3}. The high order multipoles do not have any detrimental effect on the behaviour of the machine. The measurements performed on the dipoles and sextupoles indicate also magnets within the magnetic specifications.

ACKNOWLEDGEMENTS

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