PLANAR ELECTROMAGNETIC MULTIPOLE CORRECTORS FOR A CIRCULARLY POLARIZED UNDULATOR

S. Sasaki, I. Vasserman, and E. Trakhtenberg, ANL, Argonne, IL 60439, USA

Abstract

Planar electromagnetic correction lenses were designed, constructed, and installed in order to compensate skew multipole components generated by an electromagnetic circularly polarizing undulator (CPU) for the Advanced Photon Source (APS). The reason for selection of the planar configuration is that the corrector lenses should fit around a flat undulator vacuum chamber. Comparison was made between the measured strength of skew multipole components and results calculated by the 3D code RADIA [1].

1 INTRODUCTION

In the third-generation light sources, various types of insertion devices have been installed and are being used for various types of experiments. Among those devices, a planar permanent magnet undulator for generating circularly or elliptically polarized radiation has become one of the most popular, while only a few electromagnetic elliptical devices are in operation. Such devices introduce a horizontal magnetic field component as well as a vertical component. In such a device, it is highly possible to introduce higher order skew multipole components of the field integral caused by field errors. Some of these skew components are harmful to the electron beam in the storage ring. For example, a skew quadrupole introduces a coupling between horizontal and vertical motion of the particles in the beam, and a skew octupole leads to a reduction of beam lifetime.

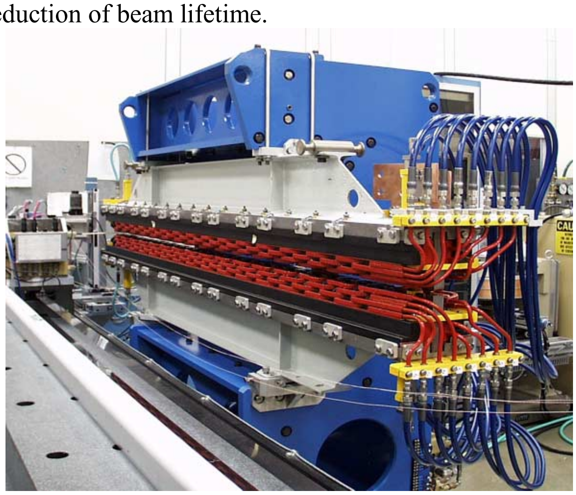

Fig. 1: View of CPU on the measurement bench.

Figure 1 shows a view of the CPU on the magnetic measurement bench [2, 3]. This device, outfitted with a skew-quadrupole correction lens and a skew-octupole correction lens, is now in operation in the APS storage ring. It was installed after making correction of dipole, multipole and skew-multipole errors. Dipole correctors and a normal quadrupole corrector are built into the jaws of the CPU.

2 DESIGN

One of the major problems of the CPU was the existence of multipole field integral components. Almost all normal and skew higher components did not meet the requirements. To solve this problem, additional trim lenses to correct skew quadrupole and skew octupole integrated field components were designed. Figures 2 and 3 show the skew quadrupole corrector lens and the skew octupole corrector lens, respectively. Planar-type structures were chosen in order to avoid interference with the vacuum chamber.

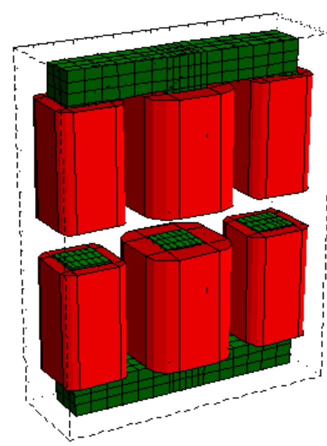

Fig. 2: Skew Quadrupole Corrector.

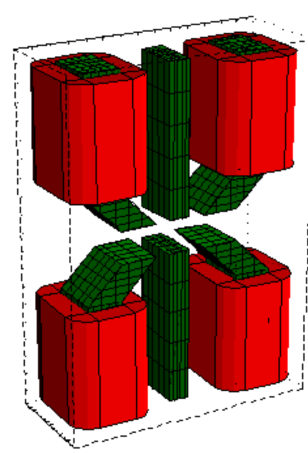

Fig. 3: Skew Octupole Corrector.

Poles of the skew-quadrupole (skew-Q) corrector and the outer poles of the skew-octupole (skew-Oct) are made of laminated iron.

3 PERFORMANCE

Magnetic field and field integral distributions along the x-axis (transverse to the undulator axis) generated by the skew lenses shown in figures 2 and 3 were calculated by using the 3-dimentional magnetic field calculation code RADIA [1]. Table 1 shows the calculated skew components. In the calculation, an inexpensive steel with carbon content less than 0.19% was assumed for the pole material.

Table 1: Calculated corrector strength per unit ampere.

	a1 (G)	a3 (G/cm^2)
Skew-Q Lens	-258	-48
Skew-Oct Lens	219	-154

The skew-quadrupole corrector is located at the upstream end of the CPU, and the skew-octupole is located at the downstream end. Maximum coil currents for a skew-Q corrector and a skew-Oct corrector were set to 6 A and 5 A, respectively.

Figure 4 shows the measured field integral distribution along the x-axis.

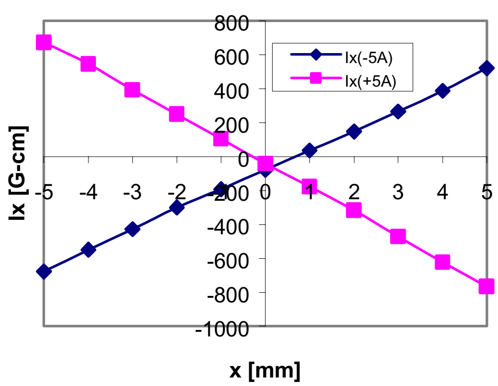

Fig. 4: Ix distribution of skew-quadrupole corrector.

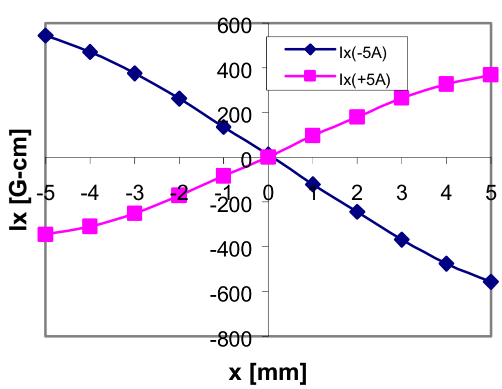

Fig. 5: Ix distribution of skew-octupole corrector.

From these figures, skew-quadrupole and skew-octupole components for both corrector lenses were evaluated, as shown in Table 2.

Table 2: Measured corrector strength per unit ampere.

	a1 (G)	a3 (G/cm^2)
Skew-Q Lens	-255	-35
Skew-Oct Lens	201	-148

By choosing an appropriate combination of current settings of both correctors, any combinations of skew-Q and skew-Oct field errors in the CPU can be corrected. In Fig. 6, corrected results of skew-Q errors together with uncorrected data are shown. Horizontal axis stands for the main vertical-field coil current of the CPU in the circular polarization mode. Figure 7 shows the results for skew-octupole errors.

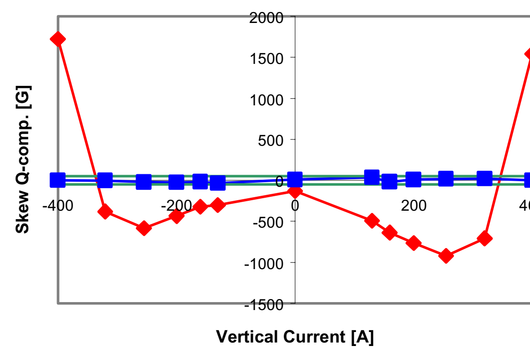

Fig. 6: Vertical current dependence of skew quadrupole component. Red diamonds correspond to the field components before correction. Blue squares correspond to those after correction. Green lines stand for the tolerance of the ring.

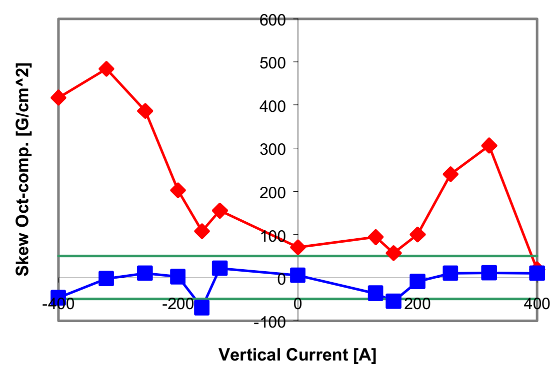

Fig. 7: Vertical current dependence of skew octupole component. Red diamonds correspond to the field components before correction. Blue squares correspond to those after correction. Green lines stand for the tolerance of the ring.

4 CONCLUSIONS

Planar electromagnetic multipole correctors for correcting skew-multipole errors of the CPU were successfully designed, fabricated, and installed.

Comparisons of calculated and actual performances were in good agreement within a reasonable accuracy.

The CPU with correctors was installed in the APS storage ring during the maintenance period in April 2001. It is now successfully being operated, and machine studies using the particle beam are underway to make the final tuning of the CPU.

5 ACKNOWLEDGMENTS

This work is supported by the U.S. Department of Energy, BES, under contract no. W-31-109-Eng-38.

6 REFERENCES

[1] http://www.esrf.fr/machine/support/ids/Public/

[2] E. Gluskin et. al.; AIP Conference Proceedings 521, p.344, Melville, NY, 2000

[3] Technical Progress Report 1999-2000, ANL/APS/TB-38, (2000).