DESIGN STUDY OF COMBINED FUNCTION TYPE MAGNETS FOR HISOR-II

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Abstract

The HiSOR-II is a storage ring planned as a successive machine of HiSOR, a present ring at Hiroshima Synchrotron Radiation Center. In this paper, discussion is made about a possible magnetic interference between a bending magnet and a quadrupole magnet. Also, calculation is made with magnetic field simulation cord RADIA to analyze interference effect and examine the possibility of adoption to HiSOR-II storage ring.

INTRODUCTION

The Hiroshima Synchrotron Radiation Center, HSRC, was founded in 1996 as an interdepartmental shared educational research facility to carry out synchrotron radiation research in the vacuum ultraviolet - soft x-ray range. In 2002, the center was reopened as a national shared-use research facility, and since then, the center has been open to researchers from all over Japan, and collaborative studies involving Japanese and overseas researchers have been conducted.

The HSRC facility possesses a small racetrack type storage ring equipped with multiple beamlines which is called HiSOR. Although the emittance of this ring is very large, overall performance level is very high especially for the photoelectron spectroscopy due to the combination of state-of-the-art beamline optical components and experimental equipments. In recent years, these beamlines are oversubscribed and there is a demand for higher brightness from beamline users. For these reasons, the plan arose for constructing the third generation light source, HiSOR-II as a successive machine of HiSOR. The HiSOR-II should also be a small storage ring in order to accommodate with existing small facility area on the university campus. This ring has the circumference about 40 m, the emittance about 14 nm-rad, and aims at the beam energy of 700 MeV.

In the HiSOR-II project, we decided to adopt electromagnets with combined function in order to save space. In addition to designing a combined function bending magnet and a quadrupole magnet, we decided to share a single return yoke between a bending magnet and adjacent quadrupole magnets in order to minimize the relative positioning errors.

In this paper, we discuss about a possible magnetic interference between a bending magnet and a quadrupole magnet. Calculation is made with magnetic field simulation cord RADIA [1] to analyze interference effect and examine the possibility of adoption to HiSOR-II storage ring. Show in figure 1 is schematics of the HiSOR-II ring and table 1 shows required specifications of these magnets for HiSOR-II [2].

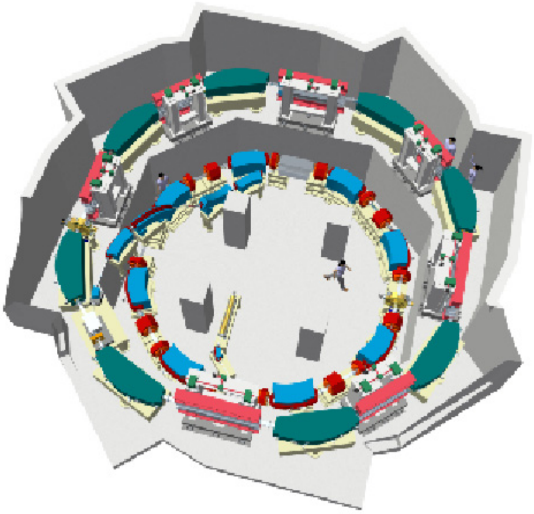

Figure 1: Layout of HiSOR-II ring.

Table 1: The specifications of the magnet of HiSOR-II.

	Bending magnet	Quadrupole magnet
Dipole component	1.400 T	0 T
Quadrupole component	2.856 T/m	11.90 T/m
Sextupole component	12.17 T/m	41.33 T/m^2
Magnet length	1.309 m	0.200 m
Distance between the magnet	0.300 m	

MODELLING OF ELECTRO-MAGNETS WITH RADIA

Firstly, we made models of a bending magnet and quadrupole magnets independently and confirmed that the required magnetic field could be generated. Then we made a model of a magnet of sharing yoke type and confirmed the distribution of the magnetic field afterwards.

We performed the harmonic analysis for the calculation of the magnetic field. The harmonic analysis is the technique analyze multipole field components at a given in the gap of magnet. Shown in Table-I is the specification of the electromagnet of HiSOR-II. The cross section of magnet of sharing yoke type and the magnetic pole shape of the bending magnet are shown in figures 2 and 3, respectively.

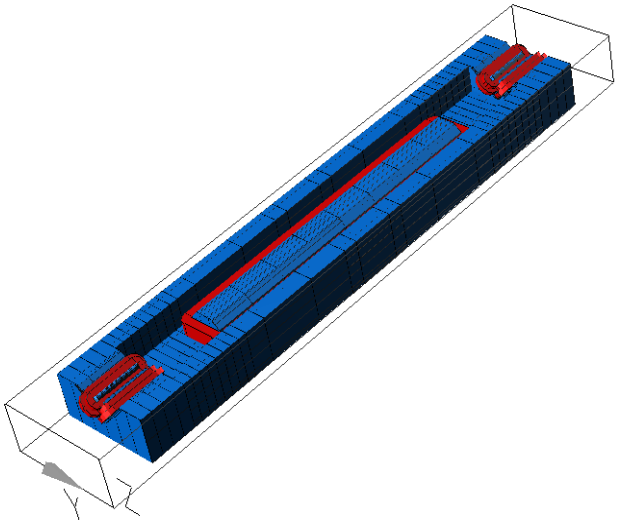

Figure 2: The cross section of sharing yoke type magnet.

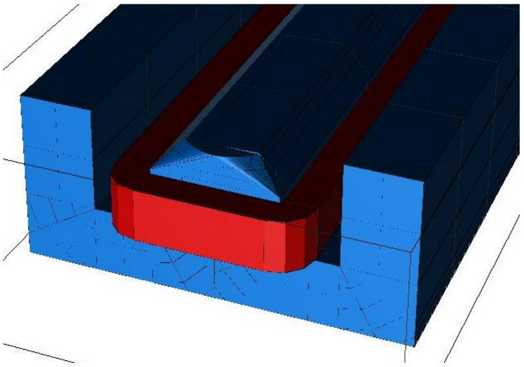

Figure 3: A view of magnetic pole shape of the bending magnet.

MAGNETIC FIELD DISTRIBUTIONS

Shown in figure 4 are the distribution of dipole, quadrupole, and sextupole components. The horizontal axis of the graph indicates the distance along the beam axis from the center (x =0) of the electromagnet.

As far as the magnetic filed distribution for each component shown in figure 4 is concerned, the magnetic interference is hardly observed even in the proximity area between magnets. In order to evaluate the interference in detail, subtraction of each field component of combined-function-magnet from separate type magnet was made as shown in figure 5.

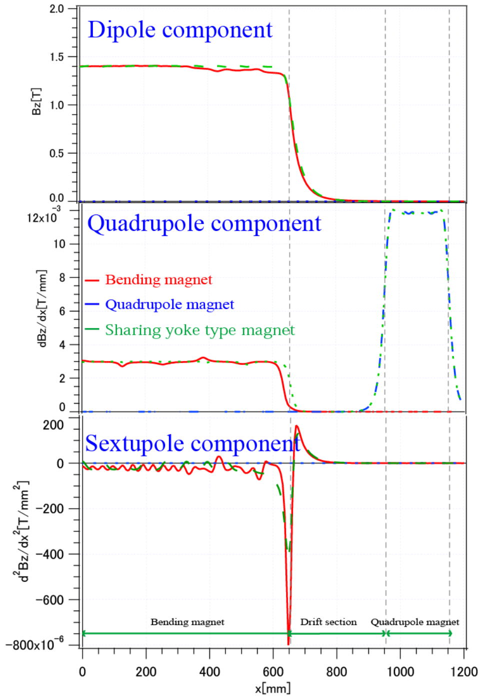

Figure 4: Magnetic field distributions of dipole, quadrupole, sextupole.

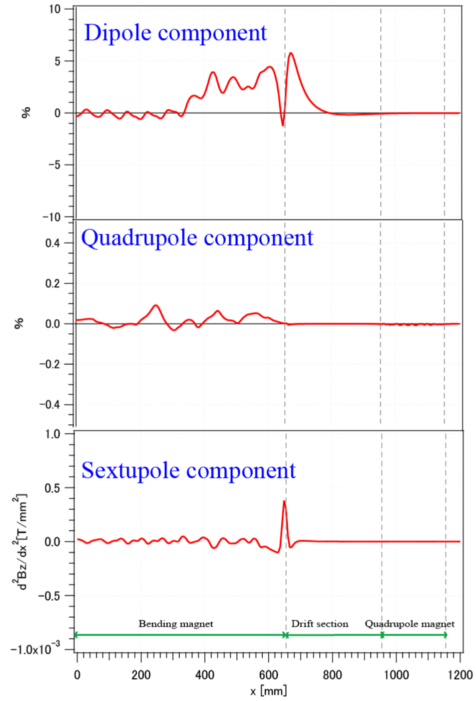

Figure 5: Subtracted magnetic field distributions.

Dipole, quadrupole, and sextupole components were not seen in the drift space between the dipole magnet and the quadrupole magnet in figure 5. We also checked whether higher multipole component error existed or not. These results for the octupole, decupole, and dodecupole components are shown in Table 2.

Table 2: Field integral error of octupole, decupole, Dodecupole.

	Octupole	**Decupole**	**Dodecupole**
Bending	-2.21×10^{-5} T/m^3	-2.21×10^{-5} T/m^4	6.66×10^{-6} T/m^5
Quadrupole	7.98×10^{-7} T/m^3	5.75×10^{-11} T/m^4	7.49×10^{-7} T/m^5
Combined	4.04×10^{-6} T/m^3	-1.04×10^{-5} T/m^4	1.10×10^{-5} T/m^5

ERROR EVALUATION AND DISCUSSIONS

There might be a possibility that a design error occurs as a realistic problem in an actual designing of this magnet. Therefore, although the distance between the real magnets is 300 mm, calculations of the magnetic interference effect for the magnet with distance of 200 mm were made, and these results are shown in figure 6 and table 3.

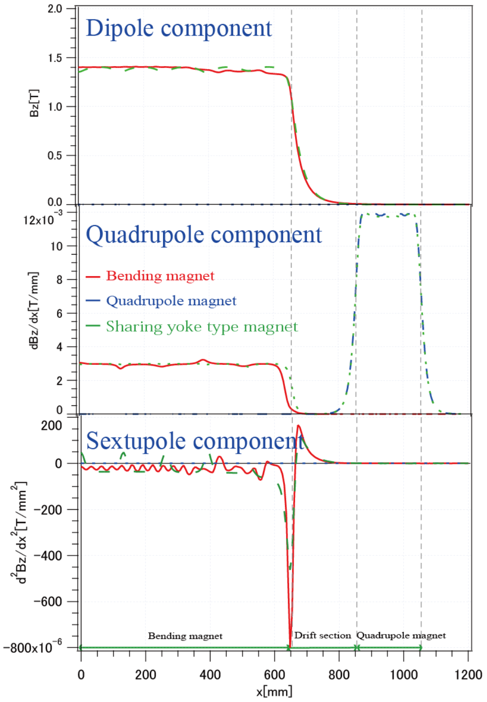

Figure 6: Magnetic field distributions of dipole, quadrupole, sextupole.

In this figure, red solid line represents the field of bending magnet, blue broken line reprensents the field of quadrupole magnet, and green dotted line reprensents the field of sharing yoke type magnet.

As one can see in figure 5, subtracted field distribution has a jagged shape. This may be due to an inappropriate segmentation in the object for RADIA calculation.

This problem may be solved by increasing the number of mesh for segmentation.

Table 3: Field integral error of octupole, decupole, Dodecupole.

	Octupole	**Decupole**	**Dodecupole**
Combined	2.60×10^{-5} T/m^3	-1.05×10^{-5} T/m^4	3.73×10^{-5} T/m^5

SUMMARY

We made a model of magnet with three-dimensional magnetic field calculation code RADIA. With this model, we examined the possibility whether the magnetic field distribution that the model magnet generates is acceptable as one of the HiSOR-II magnets.

Since no significant magnetic field interference was seen between the magnets which are under consideration, it seems that the adoption of this magnet of sharing yoke type is plausible.

The tracking simulations with the mapping data of a magnetic field provided by three-dimensional magnetic field analysis will be done. These results will be presented elsewhere.

REFERENCES

[1] O. Chubar, P. Elleaume, J. Chavanne, J. Synchrotron Radiat. 5, 481 (1998).
[2] A. Miyamoto, et al., "HiSOR-II, Future Plan of Hiroshima Synchrotron Radiation Center", in this proceedings.