# Research and Development of Magnet for HiSOR-II

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HiSOR-II has been designed as a future plan of HSRC, which will provide higher brightness VUV radiation increasing by 2 orders of magnitude compared with the present HiSOR. To reduce the construction cost and accelerator size, the magnets in the ring lattice are being designed as combined-function magnets which are capable of producing multipole field components, such as dipole, quadrupole, and sextupole. On the basis of lattice parameters of HiSOR-II, we proposed two kinds of combined-function quadrupole-sextupole magnets using auxiliary coil and pole profile adjustment, respectively [1, 2]. The magnet model is simulated using Radia [3], which is shown in Figure 1. In the combined-function magnet using auxiliary coil, the magnet pole profile is designed from a quadrupole magnet, and the sextupole magnetic field is generated by a sextupole coil on the pole face and a dipole correction coil around the pole. The quadrupole magnetic field and sextupole magnetic field can be adjusted separately. However, the structure is complicated and requires three independent power sources. As for the magnet using pole profile adjustment, the pole profile is a superimposition of the quadrupole and sextupole equipotential surfaces, which represents that the quadrupole and sextupole fields are adjusted in the design stage and fixed. Therefore, it is not compatible with flexible optics that changes in the operation.

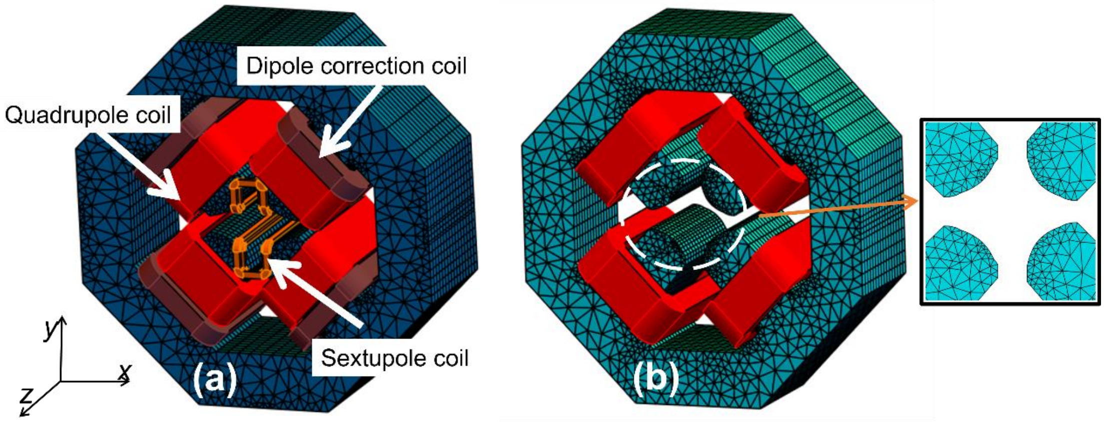


**FIGURE 1.** Combined-function quadrupole-sextupole magnets (a) with using auxiliary coil and (b) with pole profile adjustment.

To reduce the operation cost, we are also considering using an electrical/permanent hybrid magnet for energy saving [4]. The magnetomotive force is mainly generated by the permanent magnet material. The coil is assembled to provide part of magnetomotive force and adjust magnetic field strength. Such a kind of magnet can save the costs for electrical power. In addition, the magnet can get rid of water-cooling system of the coil because of a low current density. However, permanent magnets are difficult to achieve high precision and easy adjustability of the field strengths. Furthermore, there are other issues such as temperature dependence and demagnetization caused by radiation. We also found that the existence of the PM in the magnetic circuit produces a large magnetic resistance against the magnetomotive force produced by the coil. To solve this issue, we continue careful design study on the magnet configuration.

In order to apply the hybrid permanent magnet to HiSOR-II, the thermal effect compensation is being studied by using a permanent dipole magnet developed at Nagoya University [5]. In the experiment, it is observed that the variation of the dipole field strength is almost proportional to the temperature of the Permanent Magnet (PM), as shown in Figure 2.

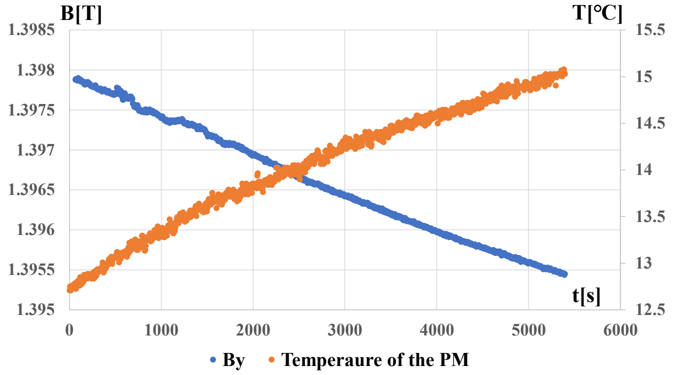


**FIGURE 2.** Variation of the $B_y$ and temperature of the PM when current density is 2A/mm$^2$.

A feedback control system for the magnetic field correction were tested. The drift of magnetic field is less than 0.0002 T (0.014%). In the future, the performance of the feedback system will be improved by increasing the precision of the measurement of the magnetic field and temperature.

## REFERENCES


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