Status of Field Measurement of the First Insertion Device

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1. Introduction

In order to allow an insertion device (ID) to be installed in a storage ring, the first and second field integrals should be as small as possible. In addition, a good field distribution, which means that the variation of the peak field is small, is necessary for high spectral intensity. Therefore, accurate field measurement is desired and some correction should be made for an ID, if necessary. We report the status of the field measurement and correction of the first insertion device.

2. Field Measurement

2-1 Construction of Apparatus

Field measurement in an ID is usually performed by a Hall probe. Because the output of a Hall probe is sensitive to temperature, some compensation should be made. Two methods are considered: One is to place the probe in a temperature-stabilized environment, the other is to correct it numerically by measuring the temperature as well as the magnetic field. We took the former method. A schematic illustration of the constructed apparatus is shown in Fig. 1. Four elements were contained in one unit. By flowing currents in the resistances and adjusting the output of one of them by PID controll, the temperature was stabilized at 28.00 ± 0.01 °C. The type of the Hall probe was "SBV603," produced by Siemens with a temperature coefficient of −0.1%/K.

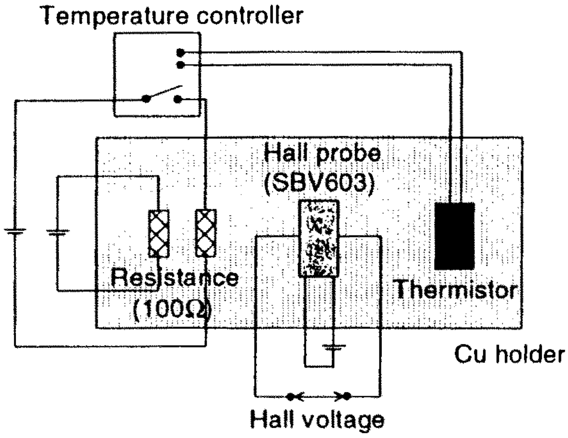

Fig. 1. Schematic illustration of the constructed apparatus.

2-2 Calibration

It is necessary to calibrate the Hall probe for measuring an absolute value of a magnetic field. The calibration was made by placing the Hall probe in a magnetic field generated by an electromagnet and comparing the Hall voltage with the magnetic field measured by an NMR (Nuclear Magnetic Resonance) probe: the calibration curve was then obtained by a least-square fitting of the calibration data with an 11th order polynomial.

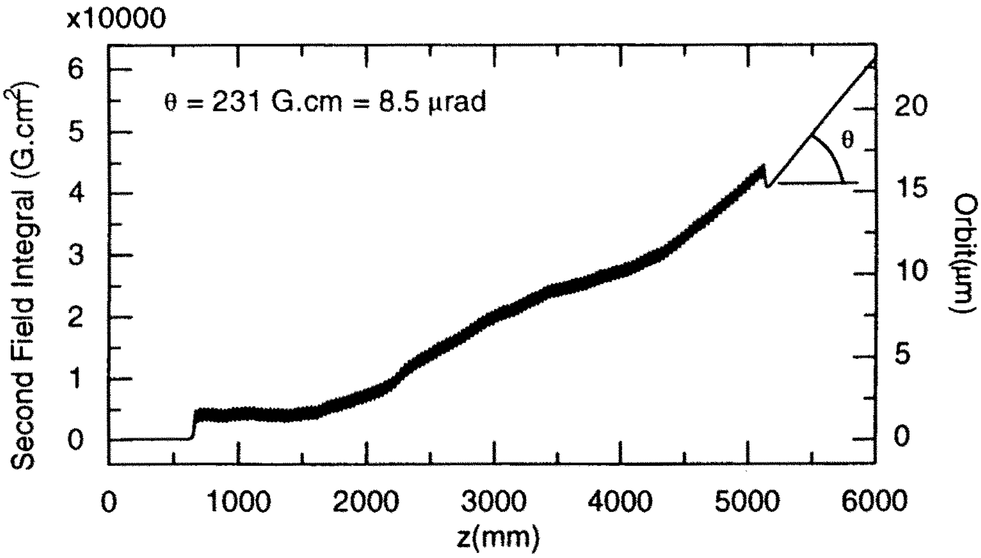

Fig. 2. Orbit calculated using the measured field before correction.

2-3 Error of the Measurement System

To investigate the error included in the measurement, we measured the magnetic field for 6 hours at the fixed place where the magnetic field was 3926 Gauss and found that the deviation was within 0.2 Gauss, which corresponded to deviation of 5.1×10^{-3} %. This could be considered to be negligibly small.

2-4 Result of Measurement

Measurement was done at the gap of 15 mm. The step was 0.5 mm and the length of the measured area was 6 m. Therefore, the number of steps was 12000 and the typical time for one measurement about three hours. The magnetic field was obtained by substituting the Hall voltage into the calibration curve. In order to obtain a practical electron orbit, the second field integral was calculated. Figure 2 shows the orbit in both units of μm and G·cm^2. At the exit of the undulator, the deflection and the displacement were found to be 8.5 μrad and 22 μm, respectively.

3. Field Correction

3-1 Method

Field correction was done by means of inserting chip magnets into the holes in magnet holders. In order to choose the magnet holder in which the magnet chip should be inserted, the first field integral for each pole, I_n, was calculated as

$$I_n = \int_{z_n}^{z_{n+1}} B_y(z)dz$$

where z_n is the n-th point where B_y becomes equal to zero. I_n means the deflection caused by the n-th pole. If I_n is large at some pole, the orbit may be "kicked" at that pole. Therefore, correction should be made so as to minimize the deviation of I_n.

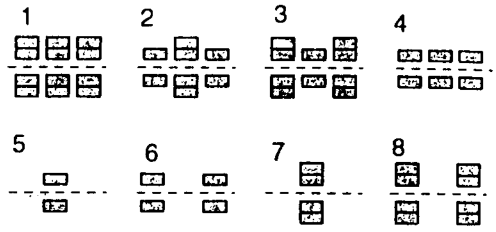

Fig. 3. Eight arrangements for inserting chip magnets.

3-2 Effect of Chip Magnets

There are some arrangements for inserting chip magnets into the holder. In each holder, there are three holes in which two or less magnet chips can be inserted. Considering the symmetry, we investigated the effect of inserting chip magnets in 8 cases of arrangement (see Fig. 3). We measured the magnetic field before and after inserting chip magnets and calculated I_n. Subtracting, the effect was obtained as the variation of I_n.

3-3 Results of Correction

We inserted chip magnets into 148 positions of poles for correction. After that, we measured again the magnetic field at the gap of 15 mm. The result is shown in Fig. 4 as the second integral or the electron orbit. It should be noted that pairs of magnets were placed at the entrance and the exit of the undulator for the end correction, such that the center of the electron wiggle corresponds to the undulator axis. For comparison with the data before correction, the vertical scale is set to be the same as that of Fig. 2. It is found that the kicks have almost disappeared and the deflection and the displacement at the exit have been reduced considerably (θ = 231G·cm → 4.87G·cm, δ = 22μm → 0.13μm).

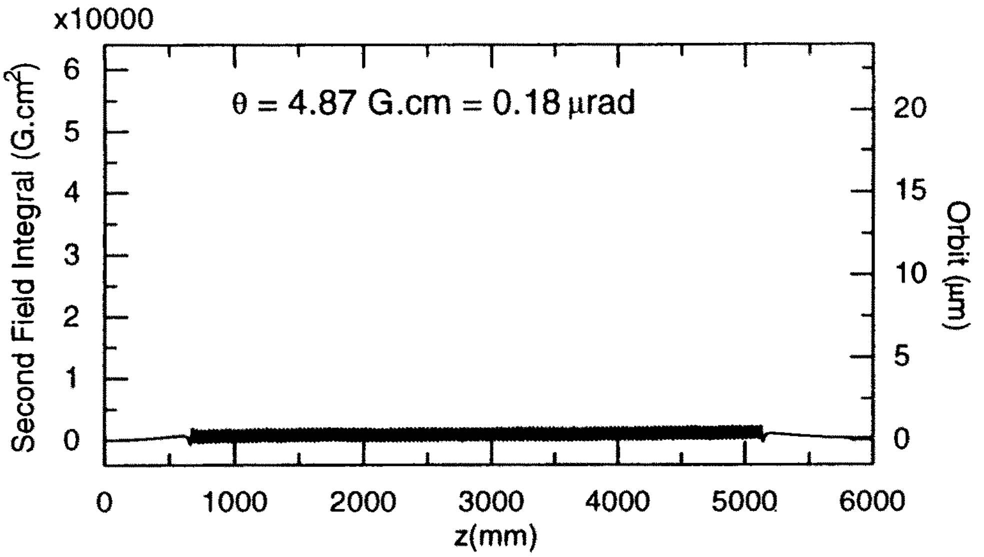

Fig. 3. Orbit calculated using the measured field after correction