Magnetic Field Measurements of Prototype Steering Magnets for the SPring-8 Storage Ring

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1. Introduction

286 horizontal steering magnets and 283 vertical steering magnets will be installed in the SPring-8 storage ring for COD correction. 6 horizontal and 6 vertical magnets are installed in the unit cell as shown in Fig. 1. A type of horizontal steering magnet and two types of vertical steering magnets will be prepared.

We have constructed all kinds of prototype steering magnets and power supplies, and measured these magnetic performances.

2. Design of Prototype Magnets

Maximum kick angle of 1 mrad for the horizontal and 0.5 mrad for vertical correction are required. Cross sectional views of prototype magnet are shown in Fig. 2(a)-(c). Horizontal steering magnet (H1) and one of vertical magnet (V1) are designed as ordinary C-shaped magnets. The other of vertical magnet (V2) is designed to particular shape as shown in Fig. 2(c), because this type of magnet is installed at the place where the wide vacuum chamber in horizontal direction are situated.

In order to reduce the indefinite value of magnetic field caused by magnetic hysteresis of the magnet core, the material which has small coercive force were chosen. For horizontal steering magnet, the oriented silicon steel plates were stamped and laminated. The laminated plates of 0.3-mm thickness were tied up by continuous-thread stud without welding to simplify the manufacture. For vertical steering magnets, the FERROPERM [1] (NKK Corp.) was used for the core. The material is new ferrous soft magnetic alloy containing 1% aluminium, which has high performance of dc magnetic properties. The FERROPERM blocks were machined and fastened.

Magnet coils were made of copper wire coated with polyester. All magnets are air-cooled.

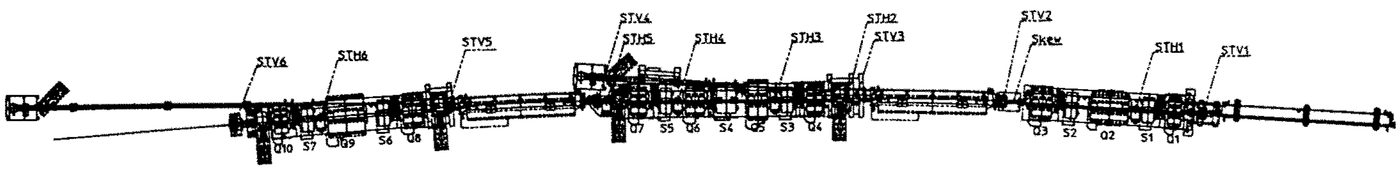
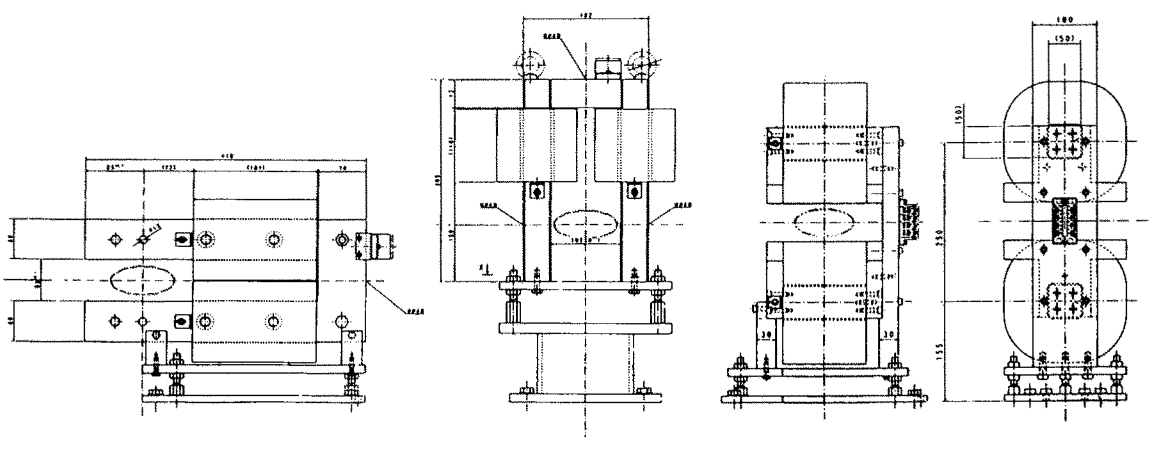


Fig. 1. Arrangement of the steering magnets in the unit cell.



(a) H1 (b) V1 (c) V2

Fig. 2. Cross sectional view of the prototype steering magnets:
(a) : Horizontal steering magnet. (b) and (c) : Vertical steering magnet.

3. Results of the Field Measurements

The magnetic fields were mapped with a hall probe on horizontal and/or vertical planes.

Figure 3 shows the relation between the excitation current and magnetic field. The fields are saturated at the range that the excitation current is higher than 5 A. As the design value of maximum current is 5 A, magnets can be operated in the linear range of excitation curve.

Figure 4 shows horizontal / vertical distribution of integrated magnetic fields along beam direction on the median plane. Field deviations less than 1 % are almost ensured at the region of beam aperture.

Change of magnetic field with temperature of the core of horizontal steering magnet (H1) is shown in Fig. 5. Magnetic field changes due to deformation of the core which is caused by conduction of the heat generated by the temperature rise of the coil. Changes of the magnetic field of both types of vertical steering magnets were smaller than 0.05 % at maximum

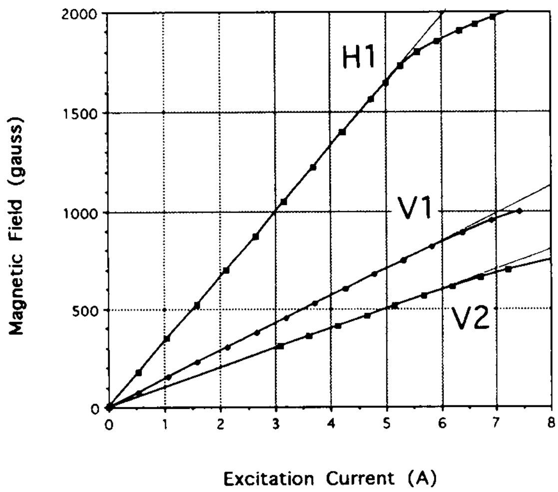


Fig. 3. Relation between the excitation current and magnetic field at the center of median plane.

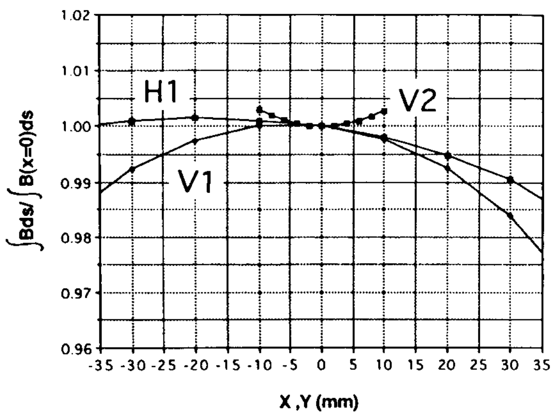


Fig. 4. Horizontal / vertical distribution of integrated magnetic fields along beam direction on the median plane.

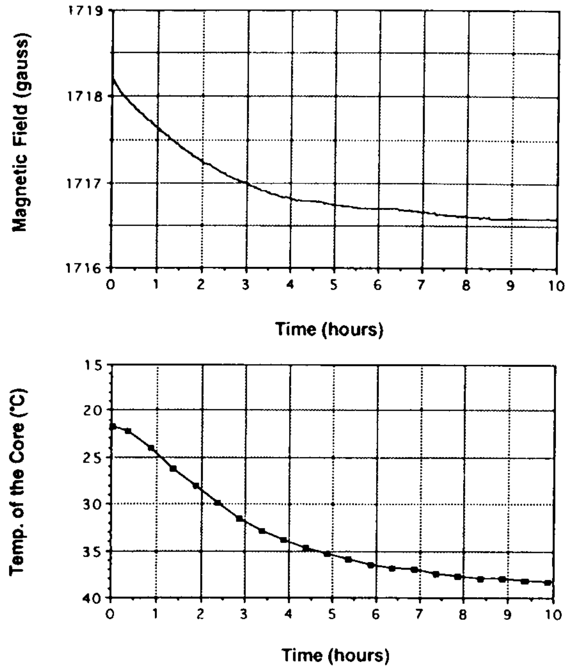


Fig. 5. Change of magnetic field with temperature of the core of horizontal steering magnet.
(a): Time dependence of the magnetic field.
(b): Temperature rise of the magnet core.
Excitation current is 5.2A.

current. But in the case of the horizontal steering magnet as shown in Fig. 5, a change of magnetic field was rather large. Thus the cross sectional area of the coil of actual horizontal steering magnet are designed larger than that of the prototype one for the decrease of heating.

4. Conclusion

The prototypes of the steering magnets were constructed and tested. Experimental results that satisfy the specification of the magnets were obtained. There were slight improvements or modifications on the actual magnets. The construction of 569 steering magnets and the installation in the storage ring have been started.

We have also made a skew quadrupole magnet for coupling correction and measured. The relevant results are obtained. The skew quadrupole magnet will be constructed and installed after beam commissioning.

References

[1] T. Omori, H. Suzuki, and T. Sampei: J. Appl. Phys., 69(8), 5927-5929 (1991).