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The Design and Magnetic Measurement of A Super Bend Dipole Magnet at SSRF

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Abstract

To increase the critical photon energy and to save space for accomodating more insertion devices, four normal bend magnet will be replaced by high field ones during the phase-II beamline project of the Shanghai Synchrotron Radiation Facility(SSRF). The design of these super bends has been finished, the first one has been manufactured and measured recently at SSRF. This water cooled electro-magnet has a total length of 1000 mm and a steering field of 2.32 Tesla. An air slot in the magnet pole was used to control the uniformity of the field integral distribution. The design and the magnetic measurement results are presented, also presented is a newly-developed field shimming method, which has shown its feasiblity and efficiency for the field integral shimming of a magnet with straight air slots in its pole.

Design specifications

The main design specifications of the super bend

Working field	2.32 T
Over all length	1000 mm
Bending angle	9°
Storage ring energy	3.5 GeV
Gap height	30 mm
Good field region	± 18 mm(H), ± 12 mm(V)
Requirement on field integral	$< 5 \times 10^{-4}$

The magnet on a test bench in the magnetic measurement labtory of SSRF

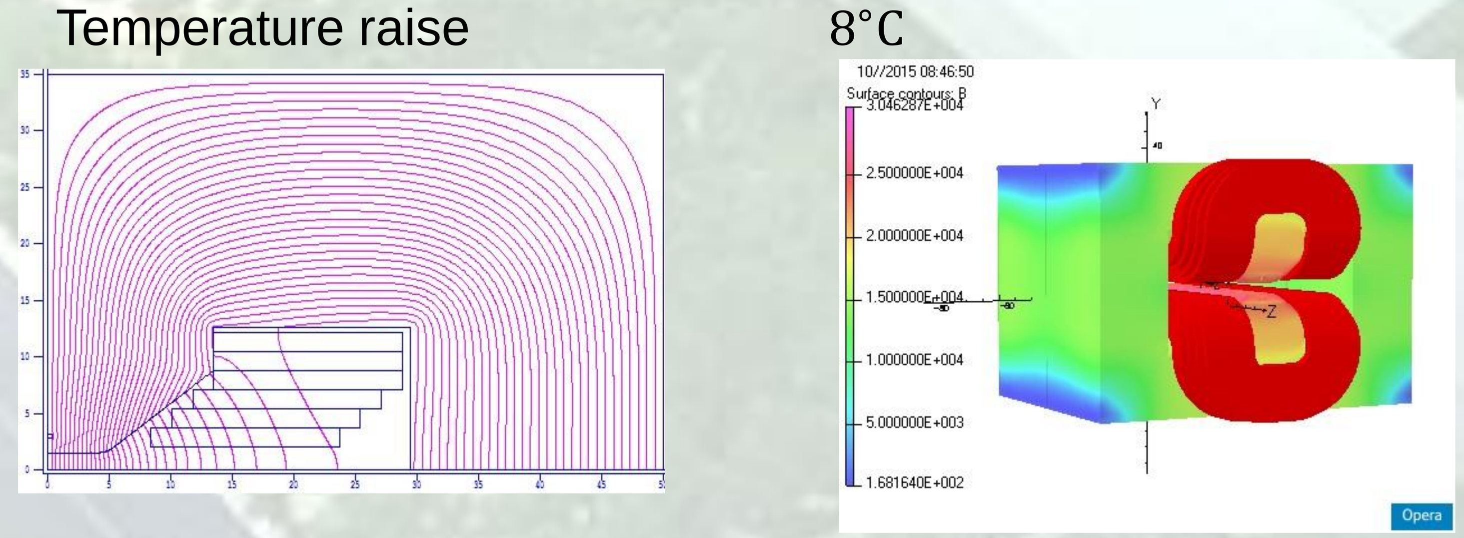
Design

The main parameters of the yoke

Yoke material	Laminated silicon steel (0.35 mm thickness)
End plate material	DT4
Yoke length	750 mm
Yoke cross-sectional size	1140×740 mm^2
Gap height	30 mm
Yoke weight	4200 kg
Pole tip width	80 mm
Pole width	270 mm
Pole side angle	50°

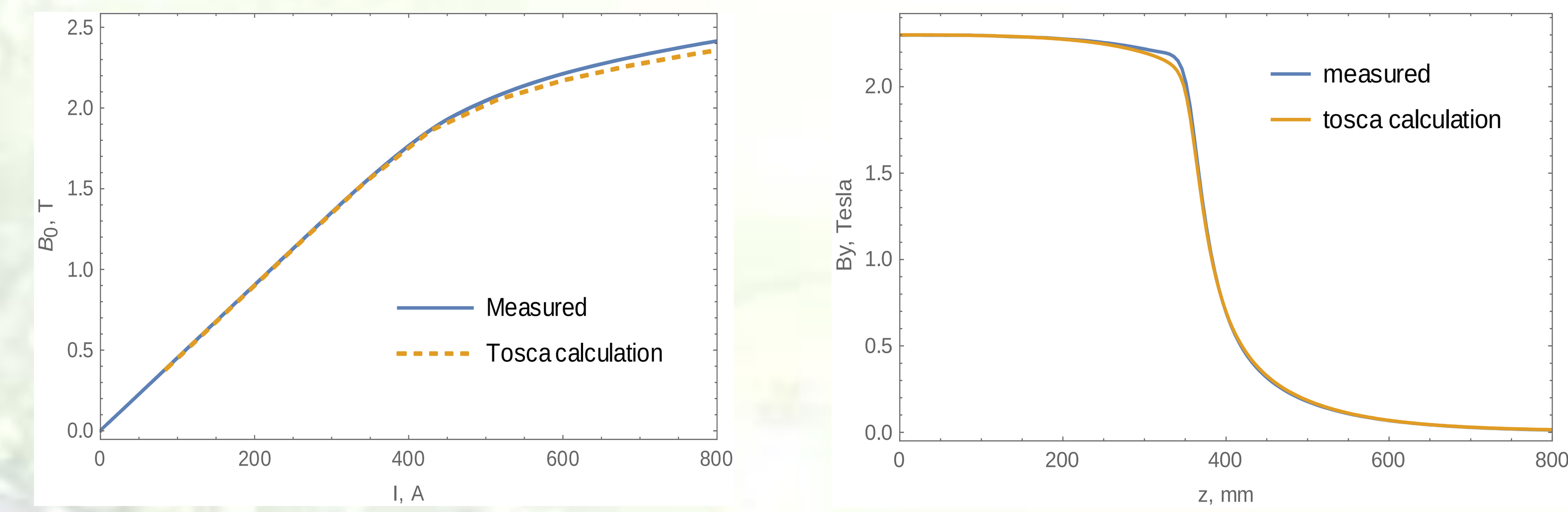
The main parameters of the coil

Coil turns per pole	54
Coil winding	9(H)×6(V) turns
Total length	1000 mm
Total weight	819 kg
Conductor outer dimension	16×16r1 mm^2
Conductor cooling tunnel size	ϕ7 mm
Conductor length	358 m
Excitation current	750 A
Resistance per magnet	0.029 Ω
Voltage drop	21.9 V
Power consumption	16.4 kW
Water pressure drop	6 kg/cm^2
Water flow speed	2.1 m/s
No. of water flow	6
Water flux	20 L/min
Temperature raise	8°C

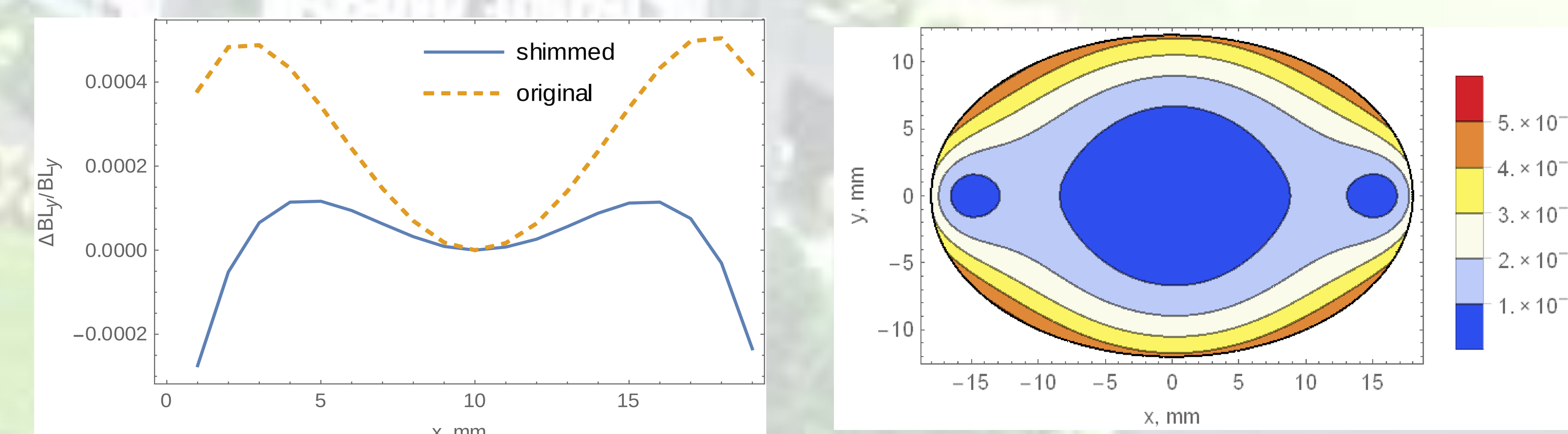


Optimizations of this magnet were based on magnetic calculations performed using both POISSON and Tosca

Measurement results



Excitation curve(left), and field distribution along center axis(right) obtained from a Hall probe measurement. Field strength reached 2.32 T at 690 A, 8% lower than the designed current. This dicrepancy which raises from lacking of informations on the BH curve of silicon steel at field strength above 2.2 T is acceptable.



The uniformity of the field integral distribution was measured using translating coil, and shimmed by placing iron bars into the air slot in the pole tips. After putting two 11 cm long iron bars into the two air slots, a field integral distribution uniformity satisfies the design requirement as shown above(left: uniformity of field integral distribution in mid-plane, right: in good field region) was obtained.

Conclusions

- The field reached 2.32 T at an excitation current of 690 A.
- The uniformity of the field integral was controlled below 5×10^{-4} within the good field region using a new shimming methond.
- This method can be applied in the shimming of the uniformity of field integrals of straight iron-dominated magnets with air slots in their poles.

The constructions of other three super bend magnets is in planning and other issues concern the installation is also been considered.