DESIGN OF A SUPERCONDUCTING UNDULATER MAGNET PROTOTYPE FOR SSRF

Zhengchen Zhang[1], Jieping Xu[1], Jian Cui[1], Wei Li[1], Ming Li[1], Junjie Xu[1], Jingfang Yu[1], Yong Jiang[1,2]
[1] Shanghai Institute of Applied Physics, Chinese Academy of Sciences, Pudong, Shanghai 201204, China,
[2] University of Chinese Academy of Sciences, Beijing, 100049, China

Abstract

A 0.65 T NbTi superconducting undulator magnet prototype with a period length of 16 mm and a period number of 5 for SSRF is designed. The magnetic field simulation shows that it is possible to obtain a peak field of 0.6 T on the beam axis at a magnetic gap of 9 mm, with a current density of 800A/mm2 in the superconducting coils. Two coil formers are machined from SAE1018 stainless steel and coated with TiO2 for insulation. The dimension of the grooves of the coil windings in the coil formers is 5 mm x 10 mm. Formvar insulated NbTi superconducting wires with a diameter of 0.6 mm are used for the 128 turn coils per core groove. A five periods core of NbTi superconducting magnet is machined from SAE1018 stainless steel and winded with copper wires.

INTRODUCTION

The Shanghai Synchrotron Radiation Facility (SSRF) is the largest scientific project in China. As a third generation synchrotron radiation facility, its purpose is to generate extremely bright X-rays that can be used in research in fields as varied as structural biology, chemical catalysis, materials science, environmental science, and medicine. The SSRF consists of a full energy electron injector, a storage ring, and beamlines. The injector accelerates electrons to 3.5 giga electron volts, then shoots them into the 432 m storage ring. Researchers all over China can apply through a peer-reviewed process for time on the beamlines. Since its opening in 2009, the facility has accommodated more than 4,700 users from over 200 universities, institutes and companies.[1,2].

Recently superconducting undulator prototypes have been studied and built in several light sources, such as ANKA, APS and NSRRC[3-18] and a superconducting undulator based beamline is proposed to supply synchrotron lights with better performance than conventional permanent magnet undulators.. To study the magnetic structure and the coil winding, a short 0.65 T NbTi superconducting undulator magnet prototype of 5 periods has been designed.

MAGNET DESIGN

The specifications of the five periods prototype SCU are showed in Table 1. To achieve a maximum 0.65 T magnetic field along the central axis in the magnetic gap, as shown in Figure 1, NbTi superconducting wires with a diameter of 0.6 mm from Western Superconducting Technologies Co., Ltd. are chosen to wind the coils. The specifications of the NbTi wires are shown in Table 2.

Table 1: Specifications of the five periods SCU Magnet Prototype

Items	Values
Max Magnetic field	0.65 T
Period number	5
Period length	16 mm
Magnetic gap	9 mm
Materials	NbTi

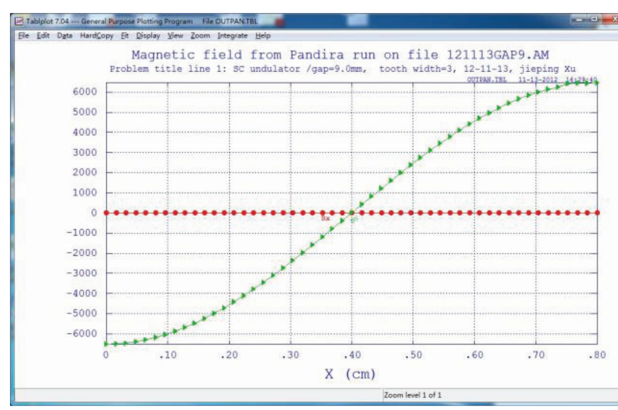

Figure 1: Magnetic field distribution in a half period along the axis of the beam.

ISBN 978-3-95450-122-9

Table 2: Specifications of the Round Cross-section NbTi wires from Western Superconducting Technologies

Items	Values
Cu:Sc Ratio	1.3
Filaments	630
Type	Monolith
Bare Size (mm)	0.54
Insulation Size (mm)	0.60
Insulation Type	Formvar
RRR (300k/10K)	≥ 80
Ic(4.2K) Test Result	415.6 A @ 2 T
	342.7 A @3 T
	294.3 A @4 T
	252.1 A @5 T
	208.0 A @6 T
	160.8 A @7 T
	100.5 A @8 T
	54.9 A @9 T

COIL FORMER DESIGN AND FABRICATION

Two coil formers of NbTi superconducting undulator magnet prototype have been designed and machined from SAE1018 stainless steel. The dimension of the grooves of the coil windings in the magnet core is 5 mm x 10 mm, as shown in Figure2. Formvar-insulated NbTi superconducting wires with a diameter of 0.6 mm are used for the 128 turn coils per core groove. The surfaces of the coil formers has been treated with 500 nm thin TiO2 for insulation.

Test winding with copper wires has been carried out to validate the feasibility of the wire arrangement in the grooves, as shown in Figure 3. The whole coil will be winded with one single wire, starting from the first groove, then to the third , the fifth, the seventh and the ninth groove, and return back over a reversing bolt, then to the tenth, the eighth, the sixth, the fourth and the second groove, thus generating opposite magnetic fields between adjacent magnetic field periods.

CONCLUSION

A 0.65 T NbTi superconducting undulator magnet with a period length of 16 mm and a period number of 5 for SSRF is designed. The magnetic field simulation shows that it is possible to obtain a peak field of 0.65 T on the beam axis at a magnetic gap of 9 mm, with a current density of 800A/mm2 in the superconducting coils. A five periods core of NbTi superconducting magnet is machined from SAE1018 stainless steel and winded with copper wires.

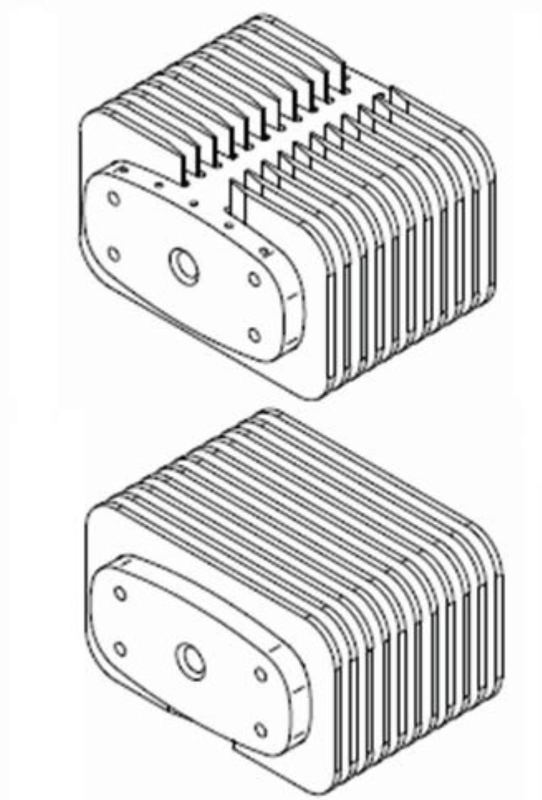

Figure 2: Sketch of the stainless steel coil former of the five periods prototype SCU magnet.

Figure 3: Photo of the five periods prototype SCU winded with copper wires.

ACHNOLODGEMENT

Project 11275254 supported by National Natural Science Foundation of China.

REFERENCES

[1] The AAAS Office Of Publishing And Member Services. Science in the Chinese Academy of Sciences, 31 August 2012: Vol. 337 no.6098 .1123.
[2] Zhao, Z. T. Storage Ring Light Sources. Reviews of Accelerator Science and Technology 3, no. 01 (2010): 57-76.
[3] S. Casalbuoni, T. Baumbach, S. Gerstl. "Training and Magnetic Field Measurements the ANKA Superconducting Undulator," IEEE Transactions on Applied Superconductivity, 2011. vol.21, iss.3: 1760-1763.
[4] Ivanyushenkov Y, Boerste K, Buffington T, *et al.* "Status of R&D on a Superconducting Undulator for the APS," Proceedings of the 2009 Particle Accelerator Conference, 2009.
[5] C. S. Hwang, J. C. Jan, C. S. Chang, *et al*. "Development trends for insertion devices of future synchrotron light sources," Physical Review Special Topics - Accelerators and Beams, 2011, 14(4): 044801.
[6] W. Walter, C. Boffo, M. Borlein, *et al*. "A New Superconducting Undulator for the ANKA Synchrotron Light Source," IEEE Transactions on Applied Superconductivity, 2010, vol.20, iss.3: 262-264.
[7] S. Caspi, S.A. Gourlay, R. Hafalia, *et al*. A superconducting undulator for 3rd-generation light sources. IEEE Transactions on Applied Superconductivity, 2002, vol.12, iss.1: 682-685.
[8] R. Rossmanith, H. O. Moser, A. Geisler, *et a*l. Superconductive 14mm period undulators for single pass accelerators (FELS) and storage rings. Proceedings of EPAC, Paris, France, 2002, 2628-2630.
[9] S. Chunjarean, J. C. Jan, C. H. Hwang, *et al*. A new field correction scheme for superconducting undulators by modification the iron pole geometry. Superconductor Science and Technology, 2011, 24, 055013.
[10] Moog E R, Abliz M, Boerste K, *et al*. Development status of a superconducting undulator for the Advanced Photon Source (APS). IPAC10, Kyoto, 2010.
[11] C. Boffo, W. Walter, T. Baumbach. The New Conduction-Cooled Superconducting Undulator for ANKA. IEEE Transactions on Applied Superconductivity, 2011. vol.21, iss.3: 1756-1759.
[12] Y. Ivanyushenkov, M. Abliz, K. Boerste, *et al.* A Design Concept for a Planar Superconducting Undulator for the APS. IEEE Transactions on Applied Superconductivity, 2011, vol.21, iss.3: 1717-1720.
[13] G. Ingold, I. Ben-Zvib, L. Solomonb, M. Woodleb. Fabrication of a high-field short-period superconducting undulator. Proceedings of the 17th International Free Electron Laser Conference, 1996, vol.375, iss. 1-3: 451–455.
[14] S. Casalbuoni, T. Baumbach, A. Grau, *et al.* Progress on the superconducting undulator for ANKA and on the instrumentation for R&D. 10th International Conference on Radiation Instrumentation, 2009, Melbourne, Australia, AIP Conf. Proc. 1234, 33-36.
[15] L. Boon, A. Garfinke. Heat Load for the APS Superconducting Undulator. Proceedings of IPAC2011, San Sebastian, Spain, 3332-3334.
[16] M. P. Alexeev, D. P. Ivanov, V. E. Keilin, *et al*. A model of a helical high field strength short period undulator. Superconductor Science and Technology, 2005, 18, 700-703.
[17] D. R. Schlueter. Undulators for short wavelength FEL amplifiers. Proceedings of the Sixteenth International Free Electron Laser Conference, 1995, vol.358, iss.1-3:44– 47.
[18] Ivanyushenkov Y, Abliz M, Doose C, *et al*. Development of a superconducting undulator for the APS. Journal of Physics: Conference Series, 2013, 425(3): 032007.

ISBN 978-3-95450-122-9