Status of developing a superconducting undulator prototype at SSRF

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Abstract:
A superconducting undulator has many advantages, such as a short cycle length, a high magnetic field strength, and a flexible adjustability of magnetic flux density. When applied in a synchrotron radiation light source, a superconducting undulator can produce x-rays with a high energy and a high brightness, which could be used in many applications, such as biological molecule structure analyses, early stage cancer diagnosis and treatments. In this paper, the status of developing a 0.6T NbTi superconducting undulator prototype with a period length of 16mm and a period number of 20 for SSRF, SCU16, is reported. The progress and technical details of the magnet design, the cryostat design, and the test coils winding are presented.

1. INTRODUCTION

Superconducting undulators were designed and constructed at many synchrotron light source [1]-[8]. A superconducting magnet for a superconducting undulator is required not only to withstand the long time high energy x-ray radiation, and the heat arising from x-rays beam imaging currents, but also to meet the demanding requirement of producing an ultra short period magnetic field with amplitudes and phases of a high degree of consistency based on axial arrayed coils. In this paper, the status of developing a 0.6T NbTi superconducting undulator prototype with a period length of 16mm and a period number of 20 for SSRF is reported. The progress and technical details of the magnet design, the cryostat design, and the coil winding are presented. Our project is planned to research niobium titanium superconducting racetrack magnets for superconducting undulators through the magnet design, the coil winding, the epoxy impregnation, and the analysis of magnet stability by shimming between layers edges, using winding clamps to make the superconducting wires align compactly, which will lay a foundation for the development of superconducting undulators for both the third phase of Shanghai Synchrotron Radiation Facility project and Shanghai Free Electron Laser project.

2. MAGNET DESIGN

The sketch of the NbTi undulator prototype SCU16 magnet former matrix is given in Fig. 1. The 20 pairs of coils are pre-stressed by a special designed structure which consists of stainless steel plates, stretched together by stainless steel screwed rods. The former can restrict the movement of the superconducting wires in magnetic fields and protect the undulator from quenches. The parameters of SCU16 are shown in Table 1.

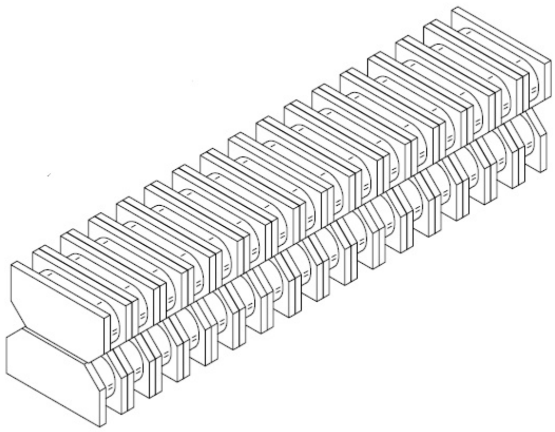

Fig. 1 Sketch of SCU16 magnet former matrix

TABLE 1. Parameters of SCU16

Parameter	NbTi
Main poles number	16
End poles number	4
Magnetic period	16 mm
Magnet pole gap	9.5 mm
Peak filed in center	0.6 T
Peak field on coil	2.6 T

3. CRYOSTAT DESIGN

The SCU16 cryogenic system consists of an external vacuum chamber, a 20K and a 50 K heat-radiation-reducing shield, four 1.5K@4.2K G-M cryocoolers with the first level cooling heads connected to the current leads and the 50 K thermal shield, while the second level cooling heads connected to the magnet array, and a liquid helium vessel with a filling tube.

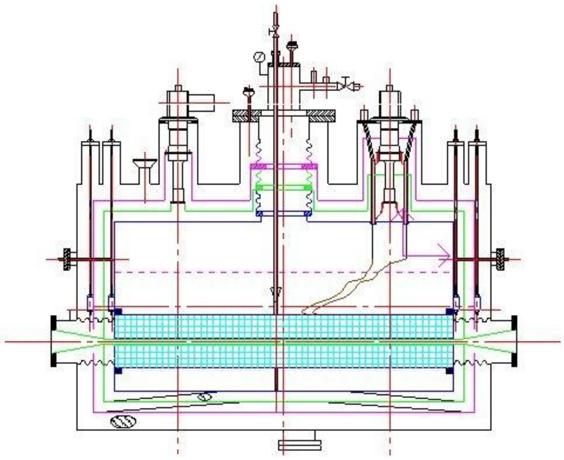

Fig. 2 Sketch of SCU16 cryostat

4. TEST COILS DESIGN AND WINDING

To valuate the performance of NbTi wires and verify the winding techniques, two solenoid test coils and a racetrack test coil are winded using a specially designed winding machine, as shown in Fig. 3, Fig. 4 and Fig. 5.

The specification of the NbTi wire and the parameters of the test solenoid coil are listed in Table 2 and Table 3.

Table 2: The specification of the NbTi wires

Parameter	Value
Cu/SC ratio	1.3
RRR	>70
Twist pitch (mm)	42
Number of filaments	54
Wire diameter (mm)	0.53
Critical current at 4.2K	213A@5T

Table 3: The parameters of the test solenoid coils

Parameter	Value
Number of layers	22

Number of turns per layer	32
Total number of turns	704
Current per turn （A）	260
Average current density (A/mm2)	245
Peak field at gap center (T)	3.46

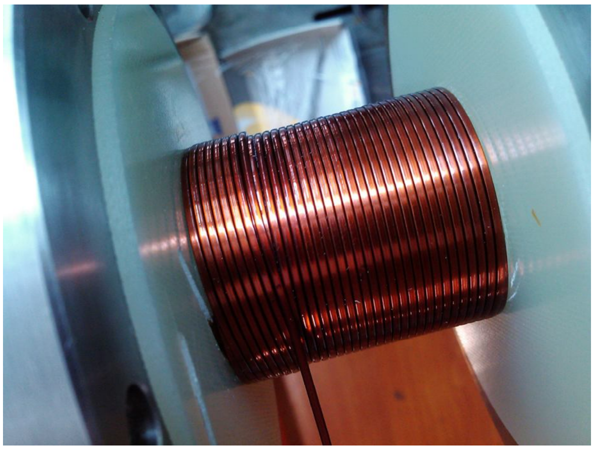

Fig. 3 Photo of a test NbTi solenoid coil

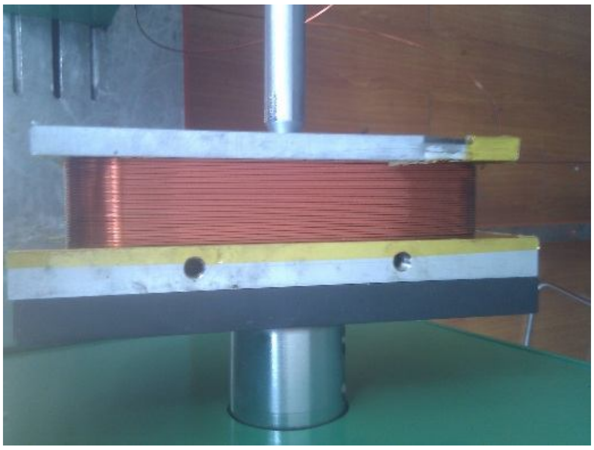

Fig. 4 Photo of a test NbTi racetrack coil

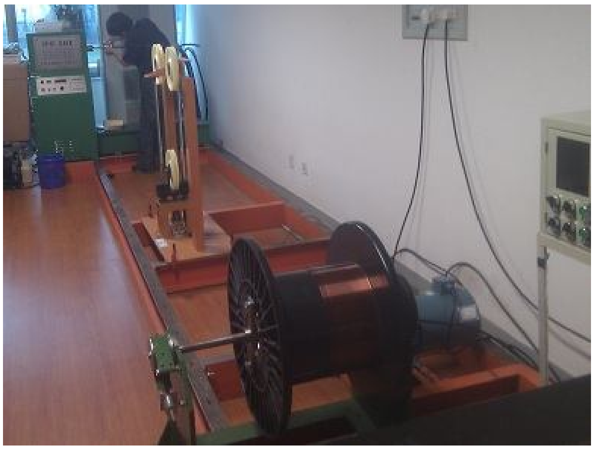

Fig. 5 Photo of the coil winding machine

4. CONCLUSION

A beamline of a superconducting NbTi undulator has been proposed for a imaging and biomedical application at SSRF. The magnet structure design, magnet field calculation and cryostat design have been carried out. Two test solenoid and a racetrack NbTi coils were winded already. The fabrication of racetrack magnets and cryostat will be started from January, 2013. An NbTi undulator demonstrator of 5 pairs of magnet poles will be assembled and tested in autumn of 2013. SCU16, a 0.6 T superconducting undulator prototype with a period length of 16 mm and a period number of 20, is scheduled to be assembled and tested in 2015 at SSRF.

5. ACKNOWLEDGMENT

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