Design study and preliminary test results of a high field ReBCO coil with a new end structure

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Abstract

IHEP (The Institute of High Energy Physics,, Chinese Academy of Sciences) is pursuing the pre-study of SPPC, a super Proton-Proton collider proposed to be built in the future. A subscale magnet named LPF1 was fabricated and tested in 2018, which reached a main field of 10.2 T at 4.2 K with NbTi and Nb_3Sn coils. The conceptual design of a high field ReBCO insert coil with a new end structure has been completed. It will be fabricated and inserted into the LPF2-i: an improved magnet based on LPF1. To take advantage of the angular dependence of the critical current in the ReBCO tapes, a new structure called balloon end is adopted to bend the tape with a larger radius and reduce the angle between the broad side of the tape and the magnetic field flux. The main design concept, fabrication process and test results of this ReBCO coil will be introduced.

Design of LPF-B

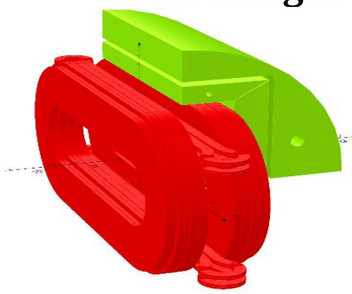
TABLE I
MAIN DESIGN PARAMETERS OF LPF2-I

Parameter	Unit	Value
Number of apertures	-	2
Bore diameter	mm	46
Number of LTS coils	-	6
Number of HTS coils	-	4
Magnetic field provided by LTS	T	12
Magnetic field provided by HTS	T	4
Peak field in LTS coils	T	12
Peak field in HTS coils	T	17
Outer diameter of the magnet	mm	500
Thickness of HTS tape	mm	0.07
Width of HTS tape	mm	4

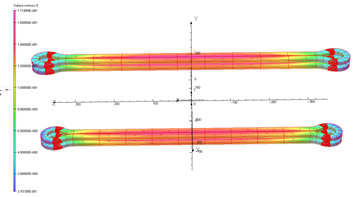
Balloon ends

Balloon ends are a combine of the anti-angular arc and the eclipse arc with the following three advantages.

Electromagnetic analysis



(a)



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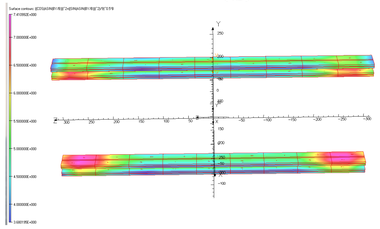


(c)

(a) LPF-B in LPF-2i with balloon ends

(b) Field distribution of LPF-B

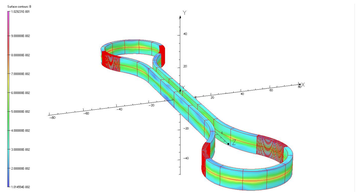
(c) equivalent vertical field of LPF-B at straight section

1. Anti-angular provides possible for bending large radius tape in narrow space.
2. Eclipse arc is a transition curve with continuous curvature, making the winding process easy and wire friendly.
3. The utilizing of ReBCO angular dependence of Jc can be fully finished in balloon ends.

The peak field in ReBCO is 17 T in this design, with the angular dependence of Jc in ReBCO tape and GL scaling it decreased to less than 7.5 T, proving that this structure has the potential to provide parallel field for ReBCO tape in racetrack magnet.

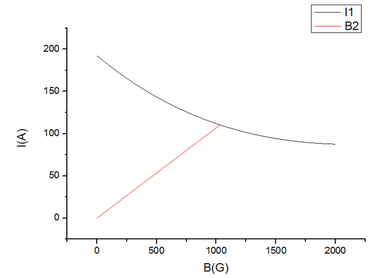
Test results

Three short ReBCO coils has been fabricated and tested in a bath of liquid nitrogen at 77K to test balloon ends. Two non-insulation coils B1 B1-2 are winded with ReBCO tape from SSTC. To better locate the position of quench in the balloon ends coil, a Kapton insulation ReBCO coil B2 has been fabricated.

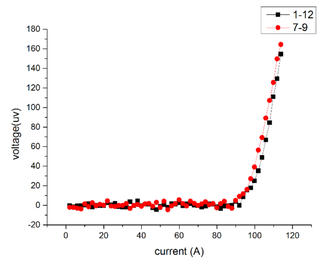


(d) B2 balloon ends insertion coil

(e) B2 kapton insulation coil



(e) Ic at different field and transfer function of B2



(f) Measured voltage and current of B2

TABLE II
TEST RESULTS OF LPF-B SERIES COILS

Coil number	B1	B1-2	B2
Cable thickness(mm)	0.22	0.38	0.5
Cable insulation	/	/	Kapton
Number of turns	12	4	5
Test Ic and loadline	77A/95%	146A/102%	110A/100%

summary

Making full use of angular dependence of ReBCO, a hybrid structure of common coil and block type decrease the peak field in ReBCO from 17 T to equivalent vertical field 7.5 T. Three short balloon coils B1 B1-2 B2 have been fabricated and tested and all three coils obtained very high loadline (>95%) at 77K. LPF2-i will be finished in the near future.

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