First Performance Test of Large-size Iron-based Superconducting Racetrack Coils at 10 T

Zhan Zhang[1,2,6], Dongliang Wang[3,4,6], Shaoqing Wei[1,2], Yingzhe Wang[1,2,4], Chengtao Wang[1,2], Zhen Zhang[1,2,4], Huanli Yao[1,2], Xianping Zhang[3,4], Fang Liu[5], Huajun Liu[5], Yanwei Ma[3,4,7], Qingjin Xu[1,2,4,7] and Yifang Wang[1,4]

[1] Institute of High Energy Physics, Chinese Academy of Sciences, Beijing 100049, People's Republic of China
[2] Key Laboratory of Particle Acceleration Physics & Technology, Institute of High Energy Physics, Chinese Academy of Sciences, Beijing 100049, People's Republic of China
[3] Key Laboratory of Applied Superconductivity, Institute of Electrical Engineering, Chinese Academy of Sciences, Beijing 100190, People's Republic of China
[4] University of Chinese Academy of Sciences, Beijing 100049, People's Republic of China
[5] Institute of Plasma Physics, Chinese Academy of Sciences, Hefei 230031, People's Republic of China
[6]Authors contributed equally to this work.
[7]Authors to whom any correspondence should be addressed.

E-mail: ywma@mail.iee.ac.cn and xuqj@ihep.ac.cn

February 5, 2021 (HP144). Circular Electron Positron Collider, Super Proton Proton Collider (CEPC-SPPC) and Future Circular Collider have been proposed by IHEP-CAS in China and CERN in Europe, for the advanced fundamental physics study in future. The high-energy accelerators for these colliders demand a large quantity of high field magnets with the requirement of significantly lower cost and superconducting materials with the capability of an application in high fields [1].

The iron-based superconductor (IBS), which was discovered in 2008, is a promising candidate for high field applications because of its high upper critical field, moderate critical temperature, strong current carrying capacity, and lower anisotropy. In 2016, the Institute of Electrical Engineering, Chinese Academy of Sciences (IEE, CAS) has successfully manufactured the 1st 100-m long 7-filamentary $Sr_{1-x}K_xFe_2As_2$ (Sr122) IBS tape using the low-cost powder-in-tube process [2]. In 2019, the IBS solenoid coils were fabricated and tested successfully at 24 T, indicating the possibility of fabricating practical IBS coils; however, the wire length of the IBS solenoid coil was only about half meter [3, 4]. Therefore, the important issue now is to make sure that the long IBS wires can be adapted to the high field magnets, especially accelerator magnets; furthermore, to find out what needs to be solved in the next step.

High magnetic field strength and high stress are two characteristics of future superconducting accelerator magnets. As a candidate material for the future accelerator magnets, it was required to check whether IBS can be adapted to this application environment. Recently, IBS racetrack coils were firstly fabricated based on 100-m long 7-filamentary Ba122 IBS tapes, and were inserted in a high field dipole magnet [5], as shown in Figure 1. High compressive stress was applied to the IBS coils during the magnet assembly and cool-down process. The recorded maximum compressive stress is about 120-130 MPa. The performance test was carried out at 4.2 K. The magnet provided a maximum background dipole field of 10 T. The highest quench current of the IBS racetrack coils reached 86.7% of I_c of the short sample at 10 T, and 81.25% of the quench current under self-field [6].

The test results of the IBS racetrack coils show that the high field performance of the large-size IBS coils is less dependent on the background field strength if compared to other practical superconducting materials, what is similar with that of the IBS solenoid coils tested previously. The performance test demonstrated the IBS conductor could be a promising candidate material for applications in high field accelerator magnets. For the next step, the team will continue to improve the current-carrying capacity and mechanical properties of IBS and develop higher performance IBS model coils and magnets.

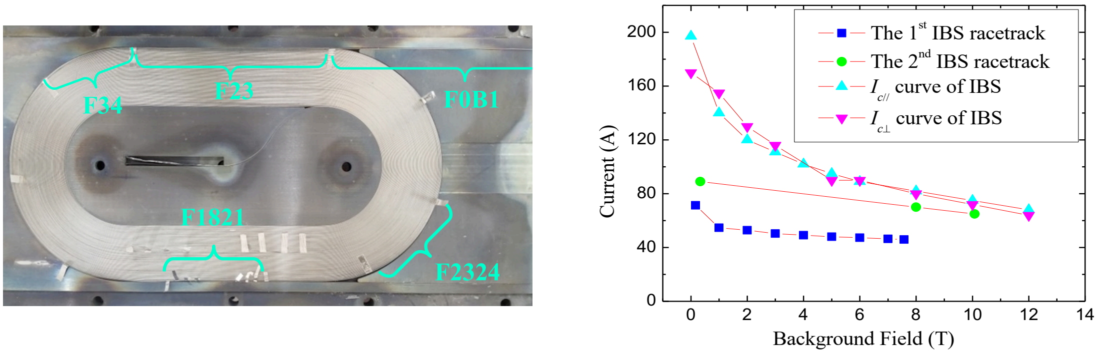

Figure 1. The IBS racetrack coil (left) and the quench current (right) with respect to the background field

Acknowledgements

The work is supported by the Strategic Priority Research Program of the Chinese Academy of Sciences Grant No. XDB25000000, the National Key R&D Program of China (Grant No. 2018YFA0704200), and the National Natural Science Foundation of China (Grant No. 11675193, 11575214, 11604335).

References

【1】 The CEPC-SPPC study group, CEPC Conceptual Design Report, 2018, (http://cepc.ihep.ac.cn/CDR_v6_201808.pdf)

【2】 Xianping Zhang, Hidetoshi Oguro, Chao Yao et al., 2017, Superconducting properties of 100-m class $Sr_{0.6}K_{0.4}Fe_2As_2$ tape and pancake coils, *IEEE Transactions on Applied Superconductivity*, 27 7300705

【3】 Dongliang Wang, Zhan Zhang, Xianping Zhang et al., 2019, First performance test of 30 mm iron-based superconductor single pancake coil under 24 T background field, *Superconductor Science and Technology*, 32 04LT01

【4】 Zhan Zhang, Dongliang Wang, Fang Liu et al., 2020, Fabrication and test of diameter 35 mm iron-based superconductor coils, *IEEE Transactions on Applied Superconductivity*, 30 4602404

【5】 Chengtao Wang, Da Cheng, Kai Zhang et al., 2019, Electromagnetic design, fabrication, and test of LPF1: A 10.2-T Common-Coil dipole magnet with graded coil configuration, *IEEE Transactions on Applied Superconductivity*, 29 4003807

【6】 Zhan Zhang, Dongliang Wang et al., 2021, First performance test of the iron-based superconducting racetrack coils at 10 T, *Superconductor Science and Technology*, 34 035021