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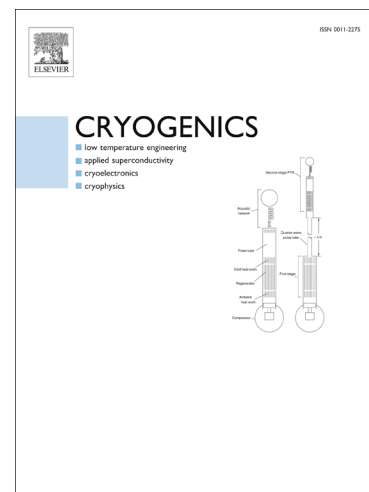
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Quench Simulation Results for a 12-T Twin-aperture Dipole Magnet

Da Cheng^{a,b}, Tiina Salmi^c, Qingjin Xu^a, Quanling Peng^a, Chengtao Wang^{a,b},
Yingzhe Wang^{a,b}, Ershuai Kong^d, Kai Zhang^{a,b}

a) Institute of High Energy Physics, Chinese Academy of Sciences, Beijing 100049, China

b) University of Chinese Academy of Sciences, Beijing 100049, China

c) Tampere University of Technology, Tampere 33720, Finland

d) University of Science and Technology of China, Hefei 230026, China

Abstract A 12-T twin-aperture subscale dipole magnet is being developed for SPPC pre-study at the Institute of High Energy Physics (IHEP). The magnet is comprised of 6 double-pancake coils which include 2 Nb₃Sn coils and 4 NbTi coils. As the stored energy of the magnet is 0.452 MJ and the operation margin is only about 20% at 4.2 K, a quick and effective quench protection system is necessary during the test of this high field magnet. For the design of the quench protection system, attention was not only paid to the hotspot temperature and terminal voltage, but also the temperature gradient during the quench process due to the poor mechanical characteristics of the Nb₃Sn cables. With the adiabatic analysis, numerical simulation and the finite element simulation, an optimized protection method is adopted, which contains a dump resistor and quench heaters. In this paper, the results of adiabatic analysis and quench simulation, such as current decay, hot-spot temperature and terminal voltage are presented in details.

Key words: quench protection; adiabatic analysis; quench simulation; heater design

1. Introduction

The Super Proton Proton Collider (SPPC) is the second stage of the Circular Electron Positron Collider (CEPC) project which aims at studying the new physics beyond the Standard Model [1]. According to the latest conceptual design report (CDR), the SPPC will adopt a 100 km storage ring in circumference and 70 TeV in center-of-mass energy [2]. The main dipole needs at least 12 T in field strength. Take consideration of the limited space in tunnel and the construction cost, an iron-based 12-T twin-aperture magnet was finally chosen as the baseline design of the SPPC because of the promising prospect of the iron-based superconductors (IBS) in the next few years [3]. In order to achieve the goal of making the final dipole magnet with a length of 14 meters, a 12-T twin-aperture subscale magnet comprised of Nb₃Sn and NbTi coils whose length is 0.3 meters is first developed to explore key technologies of the future high-field accelerator magnets like the vacuum pressure impregnation [4], bladder technology [5] and the shell-based supporting structure [6].

As the material of Nb₃Sn is strain-sensitive, a common-coil configuration [7] [8] was chosen because it can not only lower the strain level in the high field superconducting coils but also reduce the difficulty of the coil winding. The detailed design of the subscale magnet was illustrated in ref. [9]. Due to the symmetry of the coils, attention will be paid only to the first quadrant of the magnet. Fig. 1 shows the coil cross section in the first quadrant. The first 2 layers are Nb₃Sn double-pancake coils, while the other 4 layers are the NbTi ones. Each layer of the coils has 32 turns of cables. The diameter of the beam pipe is 10 mm. Fig. 2 shows the 2D field distribution in the coils and yoke computed with ROXIE [10]. The peak field is located at the inner surface of the Nb₃Sn coils, which reaches 12.03 T with the operating current of 5620 A. The total stored energy in the magnet is 0.452 MJ which will lead to a very high temperature after quench if without the quench protection system.

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