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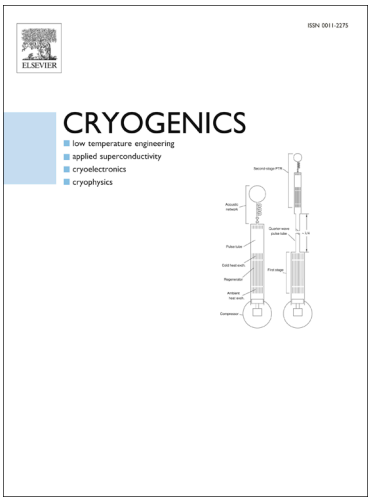

Review article

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Design, modification and test of the conduction cooled high-current current leads for the superconducting magnet

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Abstract

Conduction cooled current leads, which bring the current from the room temperature terminal down to the cryogenic environment, were used in common recently in large scale superconducting accelerators for its low cost, sample design and low heat load. In practice, the current lead is designed contained in a stainless steel tube. The heat load can be incepted in steps by thermal anchors, where one end is attached to the stainless steel tube, while the other end is connected with the cold shield of the cryomodule. Since the limitation of the welding technique, a thicker stainless steel tube needs to be used, and hence the thermal anchors cannot provide enough pressure to deform the tube enough to be in direct contact with the current lead, which may lead to temperature instability and bring extra heat load to the cryogenic system. An excellent option of epoxy filled current lead can realize the fully contact and reduce the heat load effectively. This paper will present the process of the current lead design, optimization, numerical simulation and cryogenic test, the test results show that the current lead can keep in a stable operation and low heat load.

Key words: conduction cooled current lead, thermal anchor, cryomodule, Comsol multiphysics.

1. The reason to choose the conduction cooled current lead

The injection-I of Accelerator Driven Sub-critical System (ADS) in IHEP in China, which contains two cryomodules based on a 31 mbar, 2.1 K cryogenic system, was aimed to produce a 10 mA, 10 MeV, CW proton beams in order to testify the reliability of the high current proton accelerator [1,2]. To simplify the cryogenic system, the superconducting magnets use the same state of liquid helium as that of the spoke cavity. The vapor-cooled current leads were abandoned since the low pressure Helium gas cannot return to the inlet of the compressor as the cooling source. On the other hand, conduction cooled current lead has advantages in the simple design and low cost, also no helium gas return line needed for the cryogenic system. There was a trend that more and more superconducting magnets, especially in the large superconducting accelerators, for examples CERN LHC, European XFEL, etc.[3,4,5,6] had selected the conduction cooled current leads used in the low current. For high current, modified hybrid current leads were used to reduce the heat load much more[4,5], where high temperature superconductor (HTS) such as Bi2223 were vacuum soldered on the surface of the copper or stainless core to bypass the electric current.

Fig. 1 shows the schematic layout of ADS injection-I. Two cryomodules (Labeled as CM1+CM2), with each consists of 7 low-β superconducting spoke cavities, 7 superconducting magnets and 7 beam position monitors, are used to accelerate the 10 mA proton beam from 3.2 MeV to 10 MeV. Actually, each superconducting magnet is a kind of package which contains three function magnets: a solenoid magnet for beam focusing, a horizontal dipole corrector (HDC) and a

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