Development of Binary 20 kA Bi-2223 HTS Current Leads for the NHMFL Series-Connected Hybrid Magnet

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Introduction

A development program for a set of binary current leads for the NHMFL Series-Connected Hybrid magnet was initiated to use a manufacturing technology proven at the NHMFL, combined with a high-temperature superconductor (HTS) lead technology developed for CERN. This approach was undertaken in order to minimize risk to the project schedule and to minimize the cost of magnet operation.

Analysis

Current leads are the single largest heat load on the cryogenic system, so detailed thermal analysis was required to find a design optimized for minimum heat load and for adequate operational margins of safety. A design comprised of a self-demand nitrogen vapor cooled resistive heat exchanger, a liquid nitrogen thermal intercept and a high-temperature superconducting (HTS) section with Sumitomo Type G tape conductors was found by iterative trial.

A detailed analysis of the magnetic field at the warm end of the HTS section was performed in order to set requirements for the HTS tape conductors. The analysis required computation of the background field from the magnet, self-field from the leads and busbar connections, and effects of external iron shielding around the magnet.

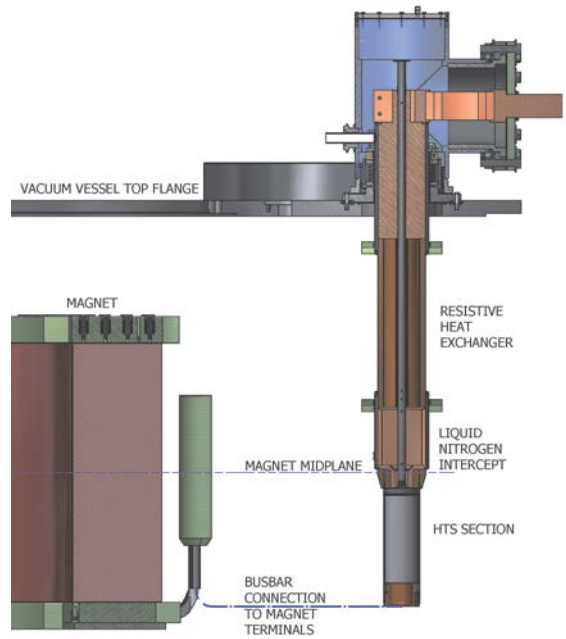

Figure 1. Cross section of lead assembly in position relative to magnet coil and vacuum vessel top flange.

Experimental

The leads are installed in a common cryostat with the magnet, so the background magnetic field at the warm end of the HTS conductor section is about 0.4 Tesla. The liquid nitrogen thermal intercept sets the temperature of the warm end of the HTS conductor section at 79 Kelvin. Performance data on Bi-2223 HTS conductors at this temperature and field were not available, so a program of in-house conductor characterization was undertaken. The data gathered from this effort was used to configure the HTS section.

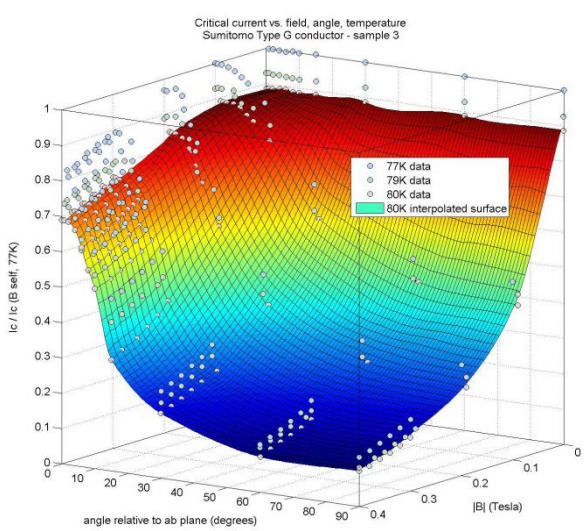

Figure 2. Plot of critical surface data for Sumitomo Type G HTS conductor vs. magnetic field magnitude and angle, and temperature.

Results and discussion

A feasible design for a binary lead was identified that met system requirements for heat load to the cryogenics, and for adequate safety margins based on measured characteristics of HTS conductors. The design provides a basis for hardware design, fabrication process development and procurement activities to follow.

Acknowledgements

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