Design and construction of a small-scale layer-wound layer-insulation (LW-LI) insert magnet with REBCO-coated conductors operating in a background magnetic field exceeding 15 T

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Abstract

Rare-earth-based barium copper oxide (REBCO) coated conductors have shown impressive performance in current transport capability and mechanical force tolerance in high magnetic field conditions, so their application as layer-wound insert magnets for the construction of a high-field nuclear magnetic resonance (NMR) superconducting magnet is reasonably expected. However, the quench protection in REBCO magnets is a critical problem; adopting layer-insulation winding methods can provide the magnet with self-protecting capability and low magnetic field delay characteristics. To verify the feasibility of the manufacturing process for the layer-wound magnet and to accumulate technological experience for the subsequent construction of high field NMR magnets, a layer-wound layer-insulation (LW-NI) insert magnet was fabricated with REBCO-coated conductors. The winding has an inner diameter of 40 mm, an outer diameter of 42 mm, and a total height of 66 mm; nine layers of the insert magnet were wound with 16 turns per layer. The layer-wound magnet successfully energized with a current of 520 A and generated a self-field of 1.12 T in the axial direction of the magnet in an external 14 T background magnetic field (15.12 T in total) at 4.2 K. In subsequent self-field tests, the layer-insulation magnet successfully achieved an operating current of 1000A, generating a self-field of 2.2 T at 4.2 K with a charging rate of 2A/s. During the rapid charging test with the insert magnet, the target current was 567A. The layer-insulation magnet was energized at a rate of up to 35A/s and neither quench nor performance degradation was observed.

Keywords: REBCO, insert magnet, layer-insulation, NMR magnet, rapid excitation