AN ORDINARY METHOD OF CUTTING A STAINLESS STEEL BEAM TUBE INSIDE THE SUPERCONDUCTING DIPOLE MAGNET WITHOUT DISASSEMBLY

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ABSTRACT

The 50-mm superconducting dipole magnet approximately 1.3 m in length was fabricated at LBL to provide a background field up to 7 T in the Cable Test Facility at SSCL. The dipole has a stainless steel beam tube with a 47.88-mm OD and a wall thickness of 2.095 mm which significantly reduced the usefulness of this magnet. There were many unsuccessful attempts to remove this tube at 300 K and 80 K.

The authors have devised a method of an ordinary multi-cutting process inside the magnet without its disassembly. In this article, tooling construction details with regulating cutting depth will be discussed.

INTRODUCTION

The purpose of the SSCL Cable Test Facility is to perform short sample critical current measurements on production lengths of the superconducting cables to be used in SSC magnets. One of the main components in this testing facility is a superconducting dipole magnet that provides a background magnetic field up to 7.5 T.

The dipole D16B-1 was designed in Lawrence Berkeley Laboratory (LBL) and tested in 1990. The coil windings are a two layer, cosθ variety with 4 wedges to form a reasonable arc. The inner layer cable consists of 28 strands of 0.808-mm diameter superconducting wire with the Cu:SC ratio of 1.22:1, and the outer layer cable has 36 strands of 0.648-mm diameter with a Cu:SC ratio of 1.66:1. These cables were produced using the same inner and outer edge packing fractions as the SSC cable. In order to maximize the transfer-

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function, the iron yoke was placed close to the winding with a 0.5-mm gap. Room temperature prestress is applied to the coil windings via the 25-mm thick aluminum rings to apply 70 MPa. During magnet cooldown the tension in the aluminum rings increases because the contraction of the iron yoke is less than that of the aluminum and the prestress is maintained on the windings without alteration. A stainless steel skin 3-mm thick surrounds the aluminum rings in order to ensure torsional stiffness and to react with the end loads.

The inner pair of coils were assembled on a 43.7-mm ID bore (beam) tube to protect the winding from mechanical damage and thermal isolation from the quenching sample. The stainless steel beam tube with a 44.45-mm outer diameter × 1.57-mm wall was expanded to an outside diameter of 47.57 mm by pulling a brass plug through the bore. The outer surface of the tube was insulated with 0.025-mm thick Kapton film using 50% overlap, followed by a spiral wrap of nylon monofilament flattened to a size of 0.94 × 2.44 mm for helium flow. The pitch length in the straight section is 25.4 mm and 5 mm on the ends.

LBL proposed to test a stack of SSC cable inside the extrusion holder with the external torque aluminum tube.

In 1992 SSCL was developing a new holder for a two-cable stack inside a high stress rolled G10 rod with 47-mm diameter. For this reason we adopted a solution to remove the beam tube from the dipole D16B-1 without disassembly.

In this article we outline technical information about an ordinary method of cutting the stainless steel beam tube inside the dipole.

DESIGN TOOLING

Several methods of removal had already been attempted by the SSCL including heating, cooling, and pressing. During liquid nitrogen cool down of the tube we observed that the tube contracted only to the lead end of the magnet in accordance with the properties of 304 stainless steel. Below we will explain the behavior of the tube. The authors designed a tool for cutting the tube while in the magnet without disassembly. The tool itself (Figure 1) was made up of three basic components, Cutter Body, Cutter, and Shock Dampening Rod. The cutter was machined from an EDM wire cutter that had four usable cutting edges made of M2 tool steel. In the cutter body there were two adjustable set screws for regulating the depth of the cut, which was set with a micrometer.

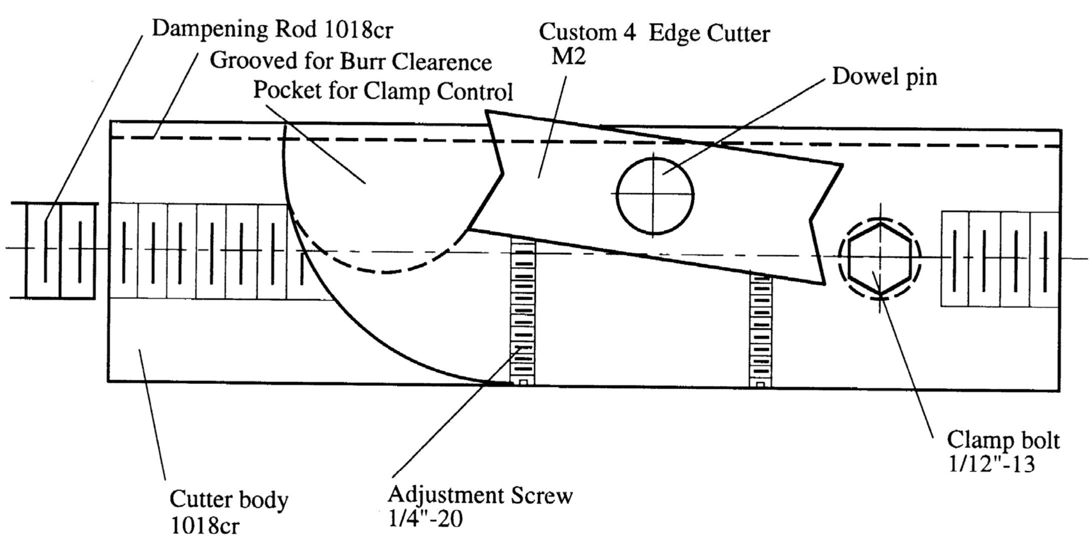

Figure 1. Cross section of tooling (not to scale).

CUTTING PROCESS

This tooling provided the opportunity to cut the tube without damaging the inner surface of the Coil in the Dipole Magnet. The cutting process consists of the following steps: (1) Precision adjustment of cutting tool to desired cutting depth. (2) Connect Dampening Rod to Cutter Body. (3) Insert Tooling through lead end of Magnet. (4) Manually applied dynamical load with hammer weight of 7 kg to Cutter Body to achieve a 12-mm long cut with a cutting depth of 0.13 mm. (5) After each completed pass through the magnet the cutter was repositioned with a new cutting edge. The process was repeated by setting the tool into the same end until the thickness of tube was decreased to 0.2 mm. This allowed the tube to collapse under a small deflection of the groove edge which permitted easy removal from the magnet.

CONCLUSION

After removal of tube, we examined the coil surface and found no damage. The vertical measurement of ID differs from the horizontal by 2.2 mm. This deviation was observed only on the first turn of the upper and lower coils. Shrinking of the tube to the lead end of the magnet can be explained by mechanical contacts between displaced turns and insulated tube.

The magnet was tested at helium temperature by the SSCL, energized with a ramp rate of 20-100 A/sec, up to 7.2 T without a quench. This indicates that the tube was removed without damage to the magnet, and the tube was not a support for the coils.

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