Testing of a Nb_3Sn Undulator Demonstration Magnet

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Introduction

The Advanced Photon Source at the Argonne National Laboratory funded MS&T to demonstrate the feasibility of short-period Nb_3Sn undulators. The primary goals are achieving high current density in the windings and finding a suitable assembly method [1]. Powder-in-Tube Nb_3Sn with a sufficiently small effective filament size is used [2]. An assembly style is chosen in which each of the two jaws is constructed from segments electrically connected by near-superconducting joints. Thus a 30-period demonstration magnet consisting of an upper and lower jaw mounted around a beam liner was designed, built and tested. See Fig. 1. This represents the first time that such a configuration is employed using Nb_3Sn.

Results

The winding tension used to guide the conductor near one of the four coil terminals proved too high, in combination with the shrinkage that occurs during heat treatment, as the conductor broke at that location during heat treatment. So the magnet was reconfigured to carry current in three out of four segments. The joint between two segments was un-done and reconfigured to a joint between a Nb_3Sn wire and an NbTi wire bundle creating a new terminal. The joint technology developed within this project thus proved suitable for effecting repairs and indicates that it should in principle be possible to repair larger segmented coils by replacing a single segment. This repair-ability is an important advantage over single-piece jaws where a single point of failure leads to the loss of the entire jaw, i.e. half the windings.

The first round of testing took place in February of 2008. The standard glass fiber conductor insulation is relatively thin in order to maximize the current density in the windings. In combination with the complex geometry of the windings, this insulation leads to imperfect electrical insulation between the windings and the yokes. Unlike in the 5-period model coils, this proved problematic leading to erratic quench behavior associated with large time constants for the decay of current through shorts. Electrical insulation of the jaws from the beam lines and the clam-shell structure large alleviated this as observed in a second round of testing. Voltage data indicates that all quenches originate in a single segment and are consistently around 640 A, about half the expected value. The *n*-value of the transition is extremely low indicating damaged conductor. It is possibly that the conductor is locally damaged in this section as an indirect result of the winding tension used. Other segments and the near superconducting joints of this demonstration magnet do not show any significant voltage before quench. Also, a separate 10-period stand-alone segment of similar design, built and tested at ANL using conductor from the same batch does reach its target critical current and current densities approaching 2 kA/mm^2.

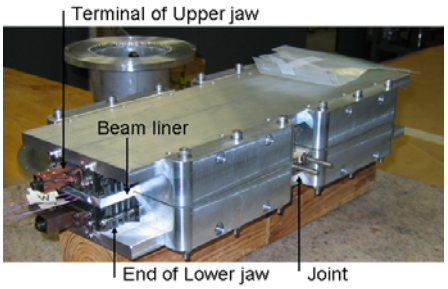

Figure 1. Picture of the magnet.

Summary

The Nb_3Sn undulator demonstration project was completed in 2008. Small segments of Nb_3Sn undulator jaws have approached the target current density of 2 kA/mm^2. Near-superconducting Nb_3Sn-Nb_3Sn joint technology has been developed that also proves suitable for effecting repairs. For the first time, a 30-period demonstration magnet consisting of two jaws around a beam liner is built and tested. Its current density does not reach its target, possibly on account of the winding tension that appears to have been too high to prevent local damage during winding. Nb_3Sn undulator technology would benefit greatly from a stronger and thinner electrical insulation to replace glass fibers.

Acknowledgements

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References

[1] H. W. Weijers, *et al*., IEEE Transactions on Applied Superconductivity, **16**, 311-314 (2006).
[3] H. W. Weijers, *et al*., IEEE Transactions on Applied Superconductivity, **17**, 1239-1242 (2007).