Short-period Nb$_3$Sn Undulator Development

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Introduction

MS&T is funded by the Advanced Photon Source (APS) at the Argonne National Laboratory to demonstrate the feasibility of short-period Nb$_3$Sn undulators. To that end we are developing a 30-period magnet consisting of an upper and lower yaw mounted around a mock beam liner. The primary challenges that are addressed with this demonstration are current density in the windings, maximizing thermal insulation between the windings and beam tube while minimizing their distance, and finding a suitable assembly method.

Research performed in previous years [1]-[2] lead to a number of choices. First is the choice of a PIT type conductor, after the IT conductor with a higher current density potential proved unstable in small model coil testing. The conductor size and available materials lend themselves to a reduction of the period to 14.5 mm, which lowers the current density compared to a 15-mm period, but would improve the overall characteristics of an user undulator. A compact structure for the beam liner was chosen that is also more robust than the original concept of a separately cooled liner, but maintaining a small gap between the windings and liner in the region where undesirable heat exchange might otherwise occur. The selected assembly approach is somewhere between the two extreme options previously investigated: each jaw will consist of two segments with one joint. Future user systems of 150 periods are foreseen to have between 5 and 10 segments per yoke using this approach. The alternate and more traditional option of a single-piece yoke for user magnets is investigated independently by APS.

Recent developments

Four yoke segments were wound, heat treated and impregnated. One segment was damaged during post-impregnation processing. Repair did not appear feasible, so the conductor was removed and the yoke cleaned. Repeating the process, with a modified impregnation procedure, went as planned. Parts for further assembly of the demonstration magnet plus cryogenic assembly were received, as well as most of the parts to match the magnet and cryogenic assembly to existing cryostats and current leads for testing. The yoke segments were joined into two jaws using the procedure that proved most reliable in previous joint research and development.

Test Plan and Status

The test plan involves two steps to separately assess the current carrying capacity of the windings and the effectiveness of the developed method to cool the windings through conduction to a separate helium-filled vessel. First, the magnet assembly is tested in a helium bath, with direct cooling of the windings, to assess the critical current density at a known and well defined temperature. Secondly, the magnet assembly is tested in a realistic cryogenic setup that relies on conduction to cool the windings. The difference in the maximum achievable operating current between those tests is directly related to the temperature differential between the windings and the helium vessel. The second test is performed with the magnet in a vertical orientation to allow field mapping using a moving Hall-effect field sensor. The first test is in preparation at the end of 2007 with the expectation of performing this test in January of 2008.

Conclusions

The construction of a short-period Nb$_3$Sn undulator demonstration magnet is nearly completed and has entered its test phase.

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References