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Thermal Analysis of He II-cooled Nb3Sn Superconducting Coil Samples for the HL-LHC Particle Accelerator Project

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The High Luminosity upgrade of the Large Hadron Collider (HiLumi-LHC) foresees the installation of Nb3Sn based dipoles (11T Dipole) and quadrupoles (MQXF) at select points of the accelerator. The precise knowledge of its thermal characteristics and heat extraction performance in response to deposited loads is essential in determining safe operating margins of the magnets. These fully impregnated Nb3Sn coils have seen an evolution in the design and impregnation process towards production coils.

In this context, experiments measuring thermal performance of two samples from each of these type of magnets in superfluid helium have been carried out at the Central Cryogenics Laboratory at CERN. The heat load is generated either via AC losses induced by a superconducting coil external to the samples or with a kapton covered foil-heater placed on the outer surface for two of the samples, while measuring the temperature of the cable layers in situ. The steady-state and transient behaviour of the samples have been studied. The transient thermal response of the samples is used to estimate the presence of helium within porous parts of the solid regions.

To simulate the heat flow in the combined superfluid-solid system of the experiment, a numerical model has been developed using open-source software. The robustness of the numerical solver has been validated with the experiment data, in particular across the domain of the heat loads used in the experiments and will be used to extend its application to models of the full magnet with distributed power deposition as expected during accelerator operation.

Category

Mechanical modelling of LTS and HTS magnets

Keywords

thermal analysis, superfluid He cooling, Nb3Sn magnet samples

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