Thermal Analysis of He II cooled Nb_3Sn superconducting coil samples

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Abstract

The High Luminosity upgrade of the Large Hadron Collider (HiLumi-LHC) foresees the installation of Nb_3Sn based dipoles (11T Dipole) and quadrupoles (MQXF) at select points of the accelerator. In contrast to the presently used NbTi non-impregnated coils, the fully impregnated Nb_3Sn coils will have a significantly different heat extraction performance in response to deposited loads. The precise knowledge of its thermal characteristics is essential in determining safe operating margins of the magnets. In this context, experiments measuring thermal performance of samples of these type of magnets in superfluid helium have been carried out at the Central Cryogenics Laboratory at CERN. The heat load is generated via AC losses induced by a superconducting coil external to the samples, with the temperature measured in situ. A numerical model has been developed using open-source software, to simulate the heat flow in the combined superfluid-solid system of the experiment. The main aim is validate the robustness of the numerical solver, in particular across the domain of the heat loads used in the experiments and in future, to extend its application to models of the full magnet. Steady-state and transient behaviour of the system has been studied and is presented here. Parametrisation studies have been used to analyse the sensitivity of the thin insulation geometries of the samples on the thermal path of the system. As an addendum, effect of presence of helium within porous parts of the solid regions is modeled to determine possible contributions to the transient thermal behaviour of the samples.