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Thermal analysis of AC loss heated Nb3Sn coil samples for the High Luminosity upgrade of the LHC

The High Luminosity upgrade of the Large Hadron Collider (LHC) foresees the installation of Nb3Sn 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 Nb3Sn 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.

With this in mind, measurements on coil-samples of these two varieties of magnets have been carried out using an experimental setup at the CERN Central Cryogenics Laboratory. The heat 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 OpenFOAM, 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.

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