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Implementation of the superfluid helium phase transition using 3D FE modeling: simulations of hot spot burnout, recovery and phase front movement

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In the thermal design of certain superconducting accelerator magnets, the emphasis is on the use of superfluid helium as a coolant. The very large effective thermal conductivity of helium below the lambda transition helps to extract heat from the coil windings during steady state and transient heat depositions. The geometry and size of the helium channels have a strong influence on the temperature distribution in the magnet.

To better understand the behavior of superfluid helium penetrating the magnet structure, 3D FE simulations can give valuable insight. Not only the helium bulk behavior is of interest, but especially the strong non-linear behavior at the interface between solid and superfluid (Kapitza conductance) is important from an engineering point of view, since relatively large temperature jumps may occur here.

This work shows how superfluid helium behavior in magnet windings can be simulated using COMSOL Multiphysics. The code is validated with experimental results taken from literature. These include burnout (exceeding the critical heat flux), recovery and subcooling of long channels filled with normal liquid helium (phase front movement). Special attention will be given to the various solid-liquid and solid-solid interfaces, which can be found in accelerator magnets.

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