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C2Po1F-07 [37]: Transient conjugate heat transfer numerical simulation in superfluid helium

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Computational simulations of superfluid helium are needed in order to improve the design of the cooling system of superconducting magnets in particle accelerators and to achieve a better understanding of the transient phenomena during magnet quenches. A conjugate heat transfer numerical model based on the C++ toolbox OpenFOAM is implemented to three-dimensional case studies involving superfluid helium and heating sources. The governing equations of the solver are modified according to the Kitamura's model, a simplified version of the two-fluid model developed by Khalatnikov which is based on the assumption that the thermomechanical effect term and the Gorter-Mellink mutual friction term prevail on the others in the superfluid component momentum equation. Simulations are performed with the thermal conductivity function of superfluid helium both from theory and the formulation used by Sato, who normalized the function according to a different heat exponential coefficient determined from data analysis. An empirical calculation of the Kapitza conductance is adopted in order to simulate the thermal resistance at the interface between helium and solids. Steady-state and transient simulations are compared to experimental data available in the literature. For such purpose, data are used from Van Sciver's experiment in a helical coil and a rectangular channel experiment conducted at CEA Paris-Saclay. The experiments comprised heaters and multiple temperature probes situated at different locations to track the temperature distribution and evolution of the superfluid helium.

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