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Numerical modelling of the quench propagation phase in the JT-60SA TF coils tested in CTF

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In the framework of the European-Japanese project JT-60SA, quench tests are performed for each one of the 18 NbTi superconducting Tokamak Toroidal Field (TF) coils in a Cold Test Facility at CEA Saclay. While launching these experimental quench tests, the conductors' Tcs are reached by progressively increasing the inlet helium temperature so as to trigger a fast discharge of nominal current (25.7 kA) on a dump resistor (6.2 mΩ). Quite complex quench dynamics were observed due to several coupled physical phenomena's influencing the quench propagation. In order to better understand the experimental analyses on coils' quench behavior, a dedicated model has been developed by coupling two computation codes, THEA (Thermal Hydraulic and Electric Analysis of superconducting cables) for 1D thermo-hydraulic modelling along the CIC (Cable-In-Conduit) conductor and Cast3M for 2D transverse thermal diffusion in a limited number of coil cross-sections. This multi-physic platform can give a better assessment for the two quench propagations' velocity and their possible variation thanks to a more realistic assessment for heat exchange through insulation in the coil between turns, pancakes, or even between Winding Pack and Casing. In this paper, the main results of these computations will be presented and compared to the quench experimental data. The analysis will focus on the quench propagation phase after its initiation sequence by studying: the longitudinal quench propagation velocity through one conductor, the transverse quench propagation velocity from turn to turn, the impact of the casing temperature (electromagnetic quench-back) on quench propagation and the impact of the full-quenched state on quench propagation.

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