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An electro-thermal coupling model of quench protection using nonlinear quench-back for superconducting magnets

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Quench protection is one of the key issues for superconducting magnets with high energy storage, especially for those wound with superconducting cables, which have low thermal conductivity between each turns. Thermal quench-back induced by a co-wound heater wire is an available quench protection scheme for the magnets wound with 6+1 type cables (6 superconducting wires wound with 1 heater wire). In the present paper, an electro-thermal coupling model is developed to deal with the dynamic coupling behaviors of electrical and temperature field inside the superconducting magnets during quench protection process based on the nonlinear quench-back. The transient evolutions of current, voltage and temperature are numerically obtained and analyzed by finite element method, which show observable quench-back features. The model is verified by comparing the numerical results with experimental measurements of a small scale model canted-cosine-theta (CCT) magnets. Furthermore, the influences of the coil inductance, operating current and dump resistor on hot-spot temperature are systematically analyzed and the relations between the quench protection parameters and peak values of terminal voltage and temperature are revealed, which are significant to the design of quench protection scheme for superconducting magnets further.

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