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Wed-Af-Or2-06: Self-protection Mechanism of Parallel-wound No-insulation, Metal-insulation, and Insulated Coils

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Parallel-wound no-insulation (PWNI) high-temperature superconducting (HTS) coil is a kind of pancake-shaped coil wound with parallel-stacked tapes, which is a promising technique with reduced ramping delay and enhanced thermal stability compared to conventional no-insulation coils wound with single tape (single-wound no-insulation (SWNI) coil). The turn-to-turn current redistribution significantly enhances the thermal stability of SWNI coils, while the situation becomes much more complicated for PWNI coils. The current redistribution between parallel-stacked tapes couples with conventional turn-to-turn current redistribution, significantly changes the self-protection mechanism under thermal disturbance, which is still unknown. This study is to illustrate self-protection mechanisms of parallel-wound HTS coils based on turn-to-turn no-insulation, metal-insulation (MI), and insulation (INS) techniques, to identify underlying causes for enhanced thermal stability of PWNI coils. Results show that the current redistribution between parallel-stacked tapes plays the most important role in improving the self-protection mechanism of PWNI coils, while the turn-to-turn current redistribution affect the thermal stability. Therefore, parallel-wound coil featuring no-insulation between parallel-stacked tapes and turn-to-turn insulation would be a promising coil technique with enhanced thermal stability. Specifically, enhancing the turn-to-turn resistivity can effectively suppress the induced coupling current, reducing the extra overcurrent risk in PWNI coils. Moreover, parallel-wound turn-to-turn INS technique can deal with one of the most threatens for no-insulation coils, quench avalanche under fluctuated background field, preventing a rapid inductive quench propagation among pancakes by minimizing the magnetic field degradation during quench. A turn-to-turn insulation framework is applied on a 20 T@20 K DEMO PWNI magnet, validating its effectiveness on further improving the self-protection stability and accelerating the ramping process. These results would provide practical guidelines for the design of high-stability HTS magnets.

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