

Closed-loop ReBCO Coil Under Varying Magnetic Field: A Study of its Current Distribution and Dynamic Losses

High-temperature superconducting (HTS) coils play an important role in fields such as MRI, superconducting motors, and magnetic shielding. Notably, closed-loop HTS coils efficiently mitigate current decay induced by heat leakage through a design without current leads and joint resistance, while the non-insulation (NI) winding process further improves their thermal stability. However, a varying external magnetic field disrupts the uniform distribution of current density and induces dynamic losses. These losses increase the coil temperature, accelerate current decay, and significantly affect the electromagnetic performance of the coil. Therefore, it is crucial to study the dynamic loss characteristics of HTS coils. In this work, a 2D axisymmetric model was established based on the H-formulation. By coupling electromagnetic and thermal modules, the variation in dynamic losses of the NI closed-loop HTS coil was analyzed when an induced current was generated under a parallel time-varying external magnetic field. The accuracy of the simulation calculations was verified by measuring the coil's temperature rise. Furthermore, the research was extended to the combined structure of insulated (INS) and non-insulated (NI) HTS coils: for this combined structure, the current density distribution and dynamic loss variation of the coil were analyzed, and the dynamic loss characteristics of the coil under complex electromagnetic fields were discussed in detail. This study provides a theoretical basis and technical reference for optimizing the design of HTS coils and reducing their dynamic losses.

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