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Numerical evaluation of transient thermal stability of no-insulation REBCO pancake coils with non-contact area between turns

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We have been developing the No-insulation (NI) REBCO coil for applications to medical cyclotrons for cancer therapy and high-magnetic-field whole-body MRIs. NI-REBCO pancake coil is expected that can realize both high current density and high thermal stability, which are essentially trade-off relationship. Since in an NI coil, electrical insulation is eliminated, the operating current can bypass toward adjacent layers when a local defect occurs, and a local rise in temperature (hot spot occurrence) can be avoided, which allows high thermal stability of coils. Previous studies have shown that it is thermally stable when heat generation due to current bypassing toward adjacent turns through turn-to-turn contact electrical resistance is dominant. Compared to the small diameter coils for ultra-high field NMR (4.2 K operation), the density of heat generated by the current bypass to the adjacent turns is smaller in the large diameter coils (30 K operation), which are used in MRI and medical accelerators, and the local temperature rise can be suppressed resulting in higher thermal stability can be expected. However, in actual coil windings, the contact condition between turns is not uniform, and there is a possibility that an area that is not completely in contact exists. In this study, we assumed that turn-to-turn non-contact areas occur random or around the local normal transition of NI-REBCO coil. Numerical analysis was performed based on PEEC (Partial Element Equivalent circuit) model to investigate the transient stability of the NI-REBCO pancake coil using the length, the number of non-contact areas and load factor as parameters, and we examined the possibility of continuous operation.
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