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Self-healing effect from thermal runaway for uninsulated REBCO coils

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The major advantage of REBCO coils is their capability for high current density operation, typically >250 A/mm2. However, if a thermal runaway happens at such a high current density, a hot spot quickly exceeds hazardous temperatures, >300 K, resulting in permanent damage to the coil winding. This is the most serious problem for high-current density REBCO coils and a protection method is required.
The uninsulated winding method (Hahn et. al. IEEE Trans. Appl. Supercond. 212, 1592-1595, 2010) is promising for protection of high current density REBCO coils. We have demonstrated that thermal runaway is self-healed due to the current mode transition; i.e. thermal runaway triggers a transition of current flow patterns from the usual "multi-turn"mode to the "single-turn"mode, resulting in dissipation of the thermal runaway. For much higher overcurrents, the coil goes into "terminal-to-terminal current"mode, resulting in an overheated region between the electrodes.
This paper investigated (i) the effect of cooling conditions and (ii) the effect of the local Joule heating in uninsulated REBCO coils, to clarify the basic behavior of the current mode transition. For a dry-wound uninsulated coil, the transitions between the three modes are clearly observed and the transitions are reversible for charging and discharging processes. On the other hand, a paraffin impregnated uninsulated coil in a quasi-adiabatic condition showed a complicated behavior. After the transition from multi-turn mode to single-turn mode, the coil showed "terminal-to-terminal current"immediately. Then, during the discharging process, the coil did not return to multi-turn mode from single-turn mode.
The behavior of current mode transition and the effect of cooling condition for layer-wound REBCO coils and pancake-stacked REBCO coils will be also investigated.

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