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Numerical Evaluation on Mechanical Behavior of No-insulation REBCO Pancake Coils in Skeleton Cyclotron

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We are developing a high-Tc superconducting (HTS) air-core compact cyclotron, named Skeleton Cyclotron, that can accelerate various particles and variable energy for radio isotope (RI) production. The coil system of Skeleton Cyclotron consists of circular and noncircular REBCO coils for high magnetic field strength and high current density. However, the higher operating current density leads to lower thermal stability. No-insulation (NI) winding technique have been proposed as a technology to enable both high current densities and high thermal stabilities. The multiple REBCO coils in Skeleton Cyclotron are applied NI winding technique. The electromagnetic and thermal behaviors in NI coil differs from those in conventional insulated coils during charging, discharging, and quenching. In NI coils, the current flows not only in the circumferential direction of the winding but also in the inter-turn direction. As a result, the current distribution and electromagnetic stress is expected to be more complicated than that of conventional coils. The additional force and stress due to a screening current, which leads to non-uniform current distributions in the REBCO tape, has become issues. In addition, the thermal deformations and stresses are induced in REBCO coils of Skeleton Cyclotron with cryocooler conduction cooling. Each winding in NI coils can deform separately and move freely by the thermal strain and electromagnetic force. The thermal and electromagnetic stress, results in the coil experiencing more complex deformations and stress distributions. Therefore, it is necessary to investigate the mechanical behavior of multiple NI coils and reinforcement structure in Skeleton Cyclotron. In this study, we report on the numerical evaluation of mechanical properties of NI REBCO coils in Skeleton Cyclotron taking into account both the complex electromagnetic stresses unique to NI coils and thermal stresses.

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