Investigation of the Characteristic Resistance of No-Insulation and Partial-Insulation NbTi Solenoid Coils

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Abstract: In order to reduce the delays in no-insulation coils, we recently introduced a partial-insulation technique in which a number of insulation layers were added in between selected turns of the coil, demonstrating significant reduction of the charge/discharge delays due to increased characteristic resistance. Accurate estimation of the characteristic resistance in the design stage is important to predict the charging behavior of the no-insulation and partial-insulation coils. In this study, the Hertzian contact resistance matrix analysis was proposed to estimate the characteristic resistance of no-insulation and partial-insulation NbTi solenoid coils. To consider the Hertzian contact effect, the stresses within the coil were identified quantitatively using a force balance equation. From analysis of the stress on the solenoid coils, the stress induced from thermal contraction was found to be dominant, while the axial thermal stress was 6.5 times larger than the radial thermal stress. The turn-to-turn and layer-to-layer Hertzian contact radii were calculated to be 15.0 and 4.29 μm, respectively, indicating that layer-to-layer contact resistance was ca. 3.5 times larger than turn-to-turn contact resistance. Through analysis of the Hertzian contact resistance matrix, the characteristic resistance values of no-insulation and partial-insulation coils were estimated to be 20.8 and 124.2 μΩ, respectively. The reasonable agreement observed between the measured and simulated charge/discharge results validated the proposed approach for the estimation of the characteristic resistance of partial-insulation coils, as well as a no-insulation "solenoid" coil.

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