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Fri-Af-Po.06-05: Temperature stability of 25-T cryogen-free superconducting magnet during initial and subsequent ramping

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A 25 T cryogen-free superconducting magnet (25T-CSM) has been installed at the High Field Laboratory for Superconducting Materials, Institute for Materials Research, Tohoku University. It consists of low-temperature superconducting (LTS) outsert coils and a high-temperature superconducting (HTS) insert coil. The LTS coils are composed of three Nb₃Sn sections (L1–L3) and three NbTi sections (L4a, L4b and L5), employing high-strength CuNb/Nb₃Sn Rutherford cables and NbTi Rutherford cables for the respective sections. The HTS insert coil is constructed as a stack of double-pancake coils wound with high-strength Ni-alloy-laminated silver-sheathed Bi2223 tape. The LTS and HTS coils can generate 14.0 T and 11.1 T, respectively, resulting in a total field of 25.1 T for the 25T-CSM.

During the initial ramping of the LTS coils to their rated value, the temperature rise in the LTS coils was more pronounced compared to that observed during the subsequent simultaneous ramping. For instance, during the sweep from 812 A to 830 A, the temperature of the L2 coil increased from 4.5 K to approximately 5 K. To mitigate the pronounced temperature rise in the LTS coils, a special sequence with multiple plateaus at half the normal ramping rate is applied only at the initial ramping. Conversely, during the simultaneous sweeping in one-hour ramping mode in normal operation, the maximum temperature of the L2 coil just before reaching the rated current of 854 A from 0 A was approximately 5.2 K.

The temperature increase observed in the initial ramping is hypothesized to result from coil training. This study investigates the temperature rise mechanism through analyses that include considerations of wire movement and hysteresis losses, aiming to provide a quantitative explanation of the observed phenomena.

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