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Thu-Mo-Or2-07: Conduction cooling test of salient-pole no-insulation HTS field winding for synchronous motor

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Recently, due to the electrification of mobility systems such as aircraft and ships, the development of high power density propulsion systems has been actively researched. In conventional electric machines based on permanent magnets and copper, the power density is limited due to constraints in current density and magnetic field. As an alternative, high-temperature superconducting (HTS) motors, which enable high energy density operation, are emerging as a promising solution. In particular, HTS field windings with no-insulation (NI) winding technique enhance operational stability for motors due to their robustness against external disturbances. From a topological perspective, an iron-cored HTS field winding is a viable option due to its advantage in reducing HTS consumption. Additionally, a concept is emerging to integrate hydrogen fuel cells with liquid hydrogen to cool the superconducting field coils of motors. Therefore, it is necessary to verify the operational stability of the field coils at an operating temperature of 20–30 K, which is near the boiling point of liquid hydrogen. In this paper, we design and fabricate a four-pole NI HTS field winding with salient iron-core, and implement current charging experiments in a 20 K conduction-cooled environment before the motor operation test. We use a lumped circuit model with an inductance look-up table according to azimuthal direction coil current for analysis of coil voltage profile considering non-linear properties of iron-core. The following key characteristics of salient pole NI HTS field winding are discussed: (1) magnetic field rise rate differences due to contact resistivity variations between poles; (2) resistive values of the pole-to-pole electrical connection; (3) temperature gradient of coil structure.

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