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Electromagnetic Shielding Technique for No-insulation Superconducting Rotor Windings in Electrical Aircraft Propulsion

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No-insulation (NI) high temperature superconducting (HTS) machine is a kind of synchronous semi-superconducting machine with high power density and enhanced thermal stability. This technique has a great potential for electric aircraft propulsion systems, in which the NI HTS coils are used as rotor windings. However, NI HTS coils suffer from eddy currents flowing through turn-to-turn contacts in synchronous machine environment due to the absence of insulation between turns, which is induced by ripple background magnetic fields from stator windings. The induced eddy currents and losses can significantly reduce the efficiency and safety of the HTS machine. In this paper, an electromagnetic shielding technique is developed to minimize this induced eddy current and loss in NI HTS rotor windings. An equivalent circuit network model is developed to analyze the eddy current and losses of NI HTS coils exposed to ripple magnetic fields. Experiments are performed to validate the model. Then the practicability of the loss reduction using electromagnetic shielding technique is studied using both modeling and measurements. The effect of copper shielding on the induced eddy current and loss is analyzed on single NI coil and multiple NI coil system respectively. Analysis results show that copper discs can effectively reduce the eddy current loss under 30K since the resistivity of the copper is relativity lower than the equivalent turn-to-turn resistivity of NI coils. The lower the operating temperature, the more obvious the shielding effect. Since the operating temperature of the HTS machine ranges from 20 K to 30 K, the electromagnetic shielding technique based on copper plats is promising to solve the problem of eddy loss in NI HTS machine design.

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