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Wed-Af-Or15-01: Key electromagnetic characteristics of non-insulation REBCO rotor windings in machines of electrical aircraft: eddy loss and ramping delay.

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High temperature superconductor (HTS) No-insulation (NI) shows a great advantage on enhanced thermal stability. It is promising to improve the stability and safety of HTS machines in electrical aircrafts. A Marie Curie project under Horizon 2020 was started to develop highly safe HTS machines based on NI technique for electrical aircraft. A 2MW HTS synchronous motor prototype was developed based on NI technique in University of Strathclyde, UK. To reduce the eddy losses and magnetization loss, the NI coils are only applied on rotor windings, and the stator windings use copper wires. Due to the absence of turn-to-turn insulation, the NI coil suffer two critical challenges in machines: eddy loss and ramping delay.
The ripple fields from stator windings can generate an eddy current on NI rotor windings. The Joule loss generated on the turn-to-turn contacts may considerably affect the efficiency of the machine, which has never been studied. The ramping delay of NI HTS coils can lead to great challenges on the performance of the HTS machine during start-up and operating station changing. This study is to elucidate these issues and validate the feasibility of NI HTS machine. First, a numerical model is developed for the electromagnetic analysis of NI HTS coils. second, the eddy loss induced by ripple fields and ramping delay are measured on a laboratory-scale NI HTS coils using calibration-free methods. Model validation are conducted by comparing the results from simulation and measurements. Then, a 2 MW HTS synchronous design is presented, the eddy loss and ramping delay of the NI rotor magnet is analysed in the machine environment, and then they are compared with that of the insulated counterpart. The distribution of eddy loss on NI rotor windings is characterized, and its influence on the efficiency and performance of the HTS motor is analysed. Measures are proposed to reduce the eddy loss and ramping delay of NI rotor winding so that they can match the requirements of the engineering applications.

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