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Thu-Af-Po.12-02: Development of Gas Blow Thermal Coupling for High-speed HTS Rotating Machinery

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High-temperature superconducting (HTS) motors and generators utilizing HTS magnets exhibit exceptional energy efficiency and output performance due to their high current density. In these systems, maintaining the rotating HTS magnets at cryogenic operating temperatures is crucial. Specifically, the rotor requires a thermal coupling structure to enable cryogenic cooling between the stationary and rotating components. Conventional coupling methods face significant challenges, such as excessive weight and low cooling efficiency when cryocoolers are applied to the rotor. Additionally, integrating heat exchange channels into the rotor presents issues related to limited space, structural complexity, and leakage. Therefore, a more stable and reliable thermal coupling method is essential to overcome these limitations. This study introduces an thermal coupling design, termed the Gas-Blow Thermal Coupling. This system incorporates an impeller-shaped, non-contact flow path within the rotating cooling channel. The impeller actively circulates a sealed gas refrigerant, enabling efficient cooling through forced convection heat exchange with the stationary heat sink. Designed for semi-permanent operation with a sealed refrigerant system, the Gas-Blow Thermal Coupling also allows for easy assembly and disassembly. Moreover, the cooling mechanism of the stationary heat sink is adaptable to various conditions, providing flexibility in the selection of cryocoolers and refrigerants.This research verifies the operational principles of the Gas-Blow Thermal Coupling and examines its feasibility as a cooling channel that meets the specified operating conditions through structural optimization and finite element method (FEM) analysis. Based on this design, a test apparatus was fabricated to simulate the thermal load of HTS rotating machinery, and its performance was experimentally evaluated and analyzed.

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