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C2Or2B-02: Cooling method for the rotor of a superconducting motor

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Electrification has been proposed as a route to decarbonizing air travel. Conventional electric motors are too heavy to achieve the power densities required for aviation so superconducting motors for aircraft are being developed. Superconductors, however, work at cryogenic temperatures, which indispensably require a reliable and efficient cooling mechanism with a cryocooler. The successful application of superconducting technology critically relies on a proper cryogenic cooling system. The Robinson Research Institute is developing a 3 MW superconducting motor using an HTS HTS (High Temperature Superconductor) rotor operating at 50 K and MgB2 running at near 20 K for the stator. The motor is intended to run at a shaft speed of 4500-6000 rpm to directly drive a ducted fan. A key challenge is the removal of heat from a cryogenic spinning rotor to a stationary refrigerator so it can be rejected at ambient temperatures. Previous motors have utilized pumped or thermosyphoned cryogens. Transferring a cryogen to a spinning rotor requires rotary seals, usually ferrofluidic seals. The aircraft application demands a compact and low weight solution. Moreover, ferrofluidic seals are not compact and generate significant amounts of heat at high shaft speeds, needing additional cooling and thermal isolation from the cryogenic environment. This paper presents the design, modelling and testing of a concept for coupling a stationary cryocooler to a superconducting rotor in an efficient manner without ferrofluidic seals to allow compact cooling with no cryogen transfer.

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