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C1Or3D-05: Novel superconducting propulsor cooling method for All-Electric Aircraft

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Hydrogen-Electric aircraft technologies require electric propulsors to achieve the goal for zero emission. Those electric propulsors are preferably superconducting with high current density, resulting in an increased power density. Propulsors can either be partially or fully superconducting. In this paper we show a cryogenic cooling concept feasible for indirect cold mass cooling in the above 20 K or higher temperature range, depending on conductor choice.
For a number of reasons, we would not bath-cool the propulsor (direct cooling) but prefer an indirect cooling approach where field and armature windings are not directly exposed to hydrogen.
The stator of this motor is exposed to the rotating magnetic field of the field coils that rotate at e.g., 4500 rpm for the CHEETA design initiating eddy currents in the armature structure. Those AC losses need to be transferred to a cooling medium. In the proposed configuration a helical cooling coil is mounted on the inner surface of the stator. The cooling coil is configured such that liquid hydrogen can pass through the stator. We call that an armature winding cooled by highly efficient liquid hydrogen forced-flow boiling. The heat load generated from the armature due to those AC losses is quite substantial and may be around 2.3 kW.
As an example, we discuss heat transfer options across both, static and rotating surfaces for indirectly cooling of a fully superconducting motor for all-electric aircraft, where stator and rotor are exposed to a vacuum environment.
We selected and analyzed a novel rotating thermal intercept between a stationary armature and a rotating field coil not based on thermal slip rings, rotating cryocoolers, rotating thermosiphons or cryogenic immersion techniques, that is efficient and can be implemented and adapted as well for different thermal loads.

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