Contribution ID: **473** Type: **Invited Oral**

M2Or4A-04: [Invited] Overview and Progress Update on a Superconducting Powertrain for CHEETA

Tuesday 20 May 2025 17:35 (20 minutes)

The field of electrified aircraft propulsion is undergoing a transformative evolution driven by the breakthrough advancements in superconducting electrical machines and cables. This paper highlights the significant progress achieved in developing a superconducting electric drivetrain under the Center for High-Efficiency Electrical Technologies for Aircraft (CHEETA) project. The team is conducting an extensive experimental campaign to mitigate risks in critical subsystems and ensure the successful demonstration of prototypes. This paper provides a comprehensive overview of the CHEETA system, along with progress updates on development and testing efforts. Topics include system design, hydrogen storage tank development, superconducting motor and cable advancements, risk-reduction experiments, and detailed test plans.

To evaluate the integrability of a hydrogen fuel cell power architecture and a distributed propulsion system for CHEETA aircraft concepts, current developments are underway to construct a 5%-scale flight test aircraft. This configuration will utilize advanced aero-propulsive optimization capabilities in the design of the high-volume airframe system, as well as an on-board avionics package to measure flight performance during testing. The outcomes of this flight test campaign will be used to understand the feasibility of cryogenic energy storage systems in an aerodynamically efficient aircraft system.

The CHEETA liquid hydrogen composite tanks are designed for minimum weight mass fraction while satisfying all aircraft operating conditions. This paper discusses the most promising design approaches including lightweight components that penetrate the shells. As part of the testing and validation effort we compare lined as well as liner-less liquid hydrogen tank designs and model the composite outgassing modes.

A two-pole cable, junction and terminations for the CHEETA high power electrical wiring and interconnection system (EWIS) demonstration are being developed for the 750-kW rated ground demonstration. This EWIS will consist of a two-pole high temperature superconducting (HTS) cable connected in series with a cryoresistive aluminum multi-stranded two-pole cable, to partially derisk a high power cryoresistive cable branch off of a HTS main cable. The HTS and cryoresistive cables will be joined by a novel electrical and cryogenic fluid flow quick-connect junction.

CHEETA envisions a groundbreaking approach to electric aviation through a hydrogen-powered system, featuring a 2.5 MW fully superconducting electric machine. Designed to achieve a specific power exceeding 25 kW/kg and an efficiency of 99.9%, this machine leverages liquid hydrogen for cooling, enhancing overall system performance. To tackle technological challenges and reduce risks, Hinetics is developing a 750-kW cryogenically cooled electrical machine that integrates innovative cooling solutions for both the stator and rotor.

Key advancements in the CHEETA motor include the following features, with ongoing demonstrations to reduce risks: a rotor-mounted Stirling-cycle cryocooler that integrates a commercial off-the-shelf (COTS) Stirling-cycle cryocooler into a rotationally compatible configuration for closed-loop conduction cooling; a rotor cryogenic thermal management system (TMS), which incorporates a novel coil suspension system that transfers torque between the cold field winding assembly and the warm rotor shaft while minimizing conduction heat load to the cryocooler, along with innovative methods to reduce radiation heat leakage to less than 10 W; quench-tolerant HTS magnets, demonstrating the passive quench tolerance of conduction-cooled, no-insulation (NI), double-pancake (DP) high-temperature superconducting (HTS) magnets; and a lightweight slotless air-core armature, designed to handle the high dB/dt levels generated by the superconducting rotor field and featuring effective cooling using cryogenic liquids such as liquid nitrogen (LN2). Hinetics is currently prototyping the motor, which is planned for testing towards the end of 2025.

The entire drivetrain is scheduled for testing at the POETS test facility in Champaign, Illinois, in 2026. These findings contribute to the advancing field of superconducting electric propulsion, paving the way for cleaner and more efficient air transportation.

Acknowledgement: This work was funded by NASA ULI grant (80NSSC23M0063)

Author: BALACHANDRAN, Thanatheepan (HInetics Inc)

Co-authors: KOVACS, Chris (Scintillating Solutions LLC); ANSELL, Phillip (Univeristy of Illinois at Urbana-Champaign); Mr STAUTNER, Wolfgang (GE HealthCare –Technology & Innovation Center (HTIC)); BONG, Uijong (Hinetics, Inc.); Dr XIAO, Jianqiao (HInetics Inc); Dr SIRIMANNA, Samith (HInetics Inc); SALK, Noah; Mr BAUER, Phoenix (HInetics Inc); Mr VENKATARAMAN, Raatan (HInetics Inc); HAUGAN, Timothy; SUMPTION, Michael; HARAN, Kiruba (University of Illinois)

Presenter: BALACHANDRAN, Thanatheepan (HInetics Inc)

Session Classification: M2Or4A - [Special Session] Transportation II: System Level