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M4Or1A-04: [Invited] AeroCryoX: A Comprehensive Library of Cryogenic Power System Component Models for Designing Electric Aircraft

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This paper discusses AeroCryoX, a MATLAB/Simulink-based modeling library developed to support the design and analysis of cryogenic power systems of electric aircraft as part of the NASA-funded University Leadership Initiative, Integrated Zero-Emission Aviation (IZEA). IZEA aims to achieve zero-emission regional aviation through a novel hybrid powertrain architecture utilizing liquid hydrogen as fuel and cryogen. The aircraft integrates fuel cells and gas turbine-powered HTS generators, with cryogenic components operating at multiple temperatures (20-140K). Integrating thermal, electrical, and fuel systems, combined with competing design requirements of reliability, power density, and efficiency, requires a unified modeling approach. AeroCryoX provides the integrated platform, enabling comprehensive system-level analysis and optimization to find design solutions that balance the often contradictory requirements of hydrogen-powered aircraft.
AeroCryoX incorporates detailed models of crucial components of superconducting generators, fuel cells, HTS cables, protection devices, and power conversion systems (motor drives, rectifiers, DC-DC converters). The library's thermal management modules enable heat load estimation for each component and its cryogenic cooling infrastructure. The models include cryogenic transfer lines, fluid circulation impellers, and heat exchangers that couple the liquid hydrogen heat sink and gaseous helium secondary loops.
AeroCryoX tracks and optimizes hydrogen utilization across multiple systems: as fuel for both gas turbines and fuel cells, as a cryogenic heat sink in the thermal management system, and its transition between liquid and gaseous states. Components such as evaporators and hydrogen gas compressors are modeled to represent the complete hydrogen flow path through the aircraft systems.
AeroCryoX incorporates weight estimation models for all system components, enabling rapid evaluation of design trade-offs between thermal performance, system weight, and power density. This integrated approach allows designers to optimize component sizing while meeting both thermal, electrical, and weight constraints. AeroCryoX's modular architecture facilitates sensitivity analyses and system-level optimization studies, supporting informed design decisions for complex cryogenic power systems.
AeroCryoX will accelerate the development of efficient, reliable cryogenic power systems for electric aircraft by providing designers with detailed insights into system behavior, performance limitations, and optimization for next-generation electric aircraft.

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