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C3Or4A-04: Transient system-level cryogenic thermal management models of liquid hydrogen-fueled electric aircraft

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Liquid hydrogen-fueled electric aircraft is a promising approach to achieving zero-emission aviation goals, particularly when combined with high-temperature superconducting (HTS) power device technology. Liquid hydrogen serves as an energy source and a cryogenic heat sink, enabling multiple high power-density superconducting devices and conventional components onboard the aircraft. Liquid hydrogen and oxygen are used as fuel and oxidizers for turboelectric generators and fuel cells. The cooling demands of the power devices are at the temperature range between 20 and 300 K. Efficient thermal management at the system level is critical for the lightweight and space-constrained design of electric aircraft. To address safety concerns and mitigate significant pressure changes caused by the phase transitions, a thermal management system has been developed by employing multiple gaseous helium secondary cooling loops to handle the diverse cooling demands of the electrical devices. The liquid hydrogen flow rate in the primary cooling loop must be determined based on fuel consumption for power generation and the overall cooling requirements of the system. Helium flow rates in the secondary cooling loops are determined by the specific heat loads of individual electrical devices at their operating temperatures. An integrated control strategy for the primary and secondary cooling loops is essential for efficient and safe power generation demands dictated by the mission profiles. This paper outlines the details of the thermal management system, modeling methodology, and flow control schemes, focusing on developing a cryogenic thermal management system design protocol.

Author: Dr CHOI, Youngjun (Florida State University)

Co-authors: CHEETHAM, Peter (FAMU-FSU College of Engineering); PAMIDI, Sastry; KIM, Chul

Presenter: Dr CHOI, Youngjun (Florida State University)

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