Design and Modeling of the Navy Integrated Power and Energy Corridor Cooling System

by

Ivan A. Reyes

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Abstract

As part of an ongoing U.S. Navy research consortium for next-generation warships, the Design Laboratory of the MIT Sea Grant Program is developing the Navy Integrated Power and Energy Corridor (NiPEC) to underpin the vessel's power distribution system. The corridor comprises several modular compartments capable of operating independently or as part of a network to execute energy storage, conversion, protection, control, isolation, and transfer functions. The power conversion process is carried out by the corridor's integrated Power Electronics Building Block (iPEBB) based architecture. The iPEBB is a comprehensive and self-contained converter configured to provide power-dense solutions to the ship's stochastic and dynamic loads. A key challenge with the iPEBB's advanced semiconductor technology is the mitigation of its thermal management, constrained by the provision of indirect liquid cooling methods and the objective of a sailor-centric design.

This thesis used numerical analysis and modeling to design an indirect liquid-cooling system aboard U.S. Navy Surface Vessels. Guided by Department of Defense and industry requirements, a new cooling paradigm was developed, promoting human- and intra-system operations, a comprehensive component design, and a robust cooling system architecture within the NiPEC compartment footprint. Documented are the initial investigation, equipment analysis, concept selection, and proof-of-concept testing that set the foundation for future prototyping and NiPEC cooling system development.

Thesis Supervisor: Julie Chalfant
Title: Research Scientist

Thesis Supervisor: Chryssostomos Chryssostomidis
Title: Professor of Mechanical and Ocean Engineering