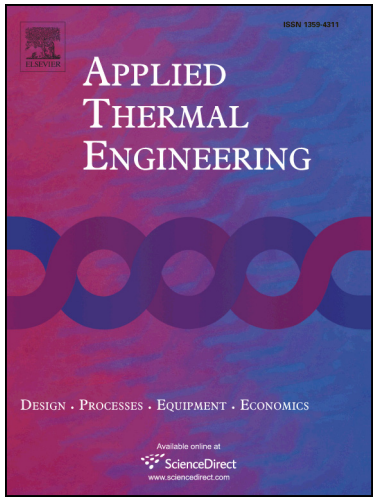

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A Thermal Management System using Ammonium Carbamate as an Endothermic Heat Sink

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Abstract: The issue of managing low-quality waste heat onboard modern high-performance aircraft represents a critical performance limitation that can severely restrict flight envelopes, preclude the integration of high-power electronics, or compromise system reliability. The principal engineering challenges to the thermal systems engineer are the large quantities of heat involved, low (and carefully controlled) coolant temperatures required, and the limited availability of heat sinks to which the waste heat must ultimately be rejected. The use of endothermic chemical reactions to serve as controllable, flight envelope-independent heat sinks has considerable potential in addressing the latter of these engineering challenges, but must be integrated as part of a systems-level approach in order to address all three - acquisition, control, and rejection. In this paper, we introduce and demonstrate a thermal management system (TMS) architecture integrating a vapor compression heat pump, phase change thermal energy storage, and heat exchanger-reactor (HEX reactor) to utilize the endothermic decomposition of ammonium carbamate as an expendable heat sink. An experimental proof-of-concept study was conducted to demonstrate acquisition of both static and time- variant thermal loads, coolant temperature regulation typical of electronics cooling applications, and rejection of the thermal load to an expendable heat sink. The proposed TMS successfully managed pulsed and steady thermal loads while maintaining a coolant temperature within 1°C of the target set point. During steady-state operation, the TMS was able to achieve coefficients of performance (COP) in the neighborhood of 3 with nearly 100% efficiency in expendable heat sink utilization; when subjected to dynamic heat loads, the use of a thermal energy storage material allowed simple control schemes to be used to maintain TMS stability.

Keywords: HEX Reactor; Ammonium Carbamate; Thermal Management; Heat Transfer; Vapor Cycle System; Thermal Energy Storage