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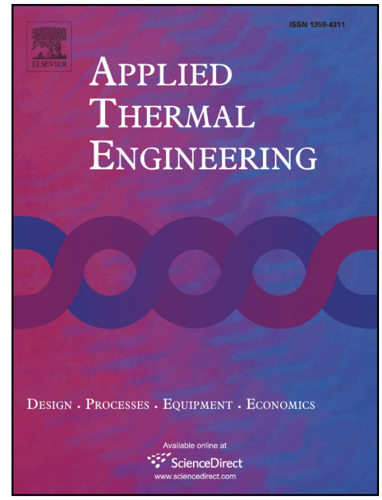

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Testing and Analysis of a Morphing Radiator Concept for Thermal Control of Crewed Space Vehicles

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Abstract

Spacecraft designed for future missions must satisfy increasingly difficult thermal requirements. Crewed vehicles, in particular, must maintain a relatively constant temperature irrespective of external conditions; this is the role of the thermal control system (TCS). A TCS may be required to reject a higher heat load to warm environments and a lower heat load to cold environments, necessitating a high turndown ratio, often on the order of 12:1. This work presents a novel radiator concept that employs shape memory alloys (SMAs) to geometrically reconfigure the radiator, enabling a lighter TCS for space exploration vehicles. The thermally-driven morphing effect allows passive (i.e. non-controlled, non-powered) control of both radiator view of space and primary surface emissivity. Thermal and radiation modeling of the morphing radiator predict a turndown ranging from 12:1 to 35:1 independent of the other aspects of TCS configuration. A system-level mass analysis shows that by enabling a single-loop architecture, this design could reduce the TCS mass by approximately 25%. Two benchtop prototypes provide proof-of-concept demonstrations of the radiator's principles of operation. Additionally, an analysis framework is developed for the first time that is capable of simulating the unique and highly nonlinear thermomechanical coupling present in the radiator. The framework provides high-fidelity results of both the stress in the radiator as well as its thermal behavior.

Keywords: radiators, thermal control, spacecraft, shape memory alloys

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