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A ZERO-ENERGY THERMAL MANAGEMENT TECHNOLOGY FOR LUNAR HABITATS

Abstract

To sustain human life and ensure the proper functioning of instruments on the Moon, it is essential to construct buildings capable of maintaining a stable and suitable temperature. However, the Moon's extreme temperature fluctuations (100K to 400K) and scarce resources pose significant challenges for thermal management in lunar structures. To address these issues, we propose a passive, zero-energy building technology that leverages environmental temperature differentials to achieve habitable conditions without external energy input. The principle behind this design is to connect the two ends of the building to a high-temperature zone and a low-temperature zone via a thermal resistance chain. Utilizing our innovative self-regulating thermal resistance technology, the resistance of this chain automatically adjusts in response to temperature variations in the two zones, ensuring that the building remains at a stable, predefined temperature between them. We validated the feasibility of this technology through a combination of experimental testing and simulation. Specifically, on the Moon, the surface temperature reaches 400K during the daytime, while the underground constant temperature zone remains at 248K. The optimal living temperature of 291K falls between these two extremes. By employing pre-programmed shape memory alloys as the thermal resistance chain, we connected the building to both the lunar surface and the underground constant temperature zone. The result demonstrated that the interior temperature of the building remained stable within the range of 291K 0.3K. This zero-energy technology provides an effective solution to the challenges posed by extreme lunar temperatures and energy scarcity, offering a viable approach for thermal management in lunar architecture.