Paper ID: 103202
student

IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Smart Materials and Adaptive Structures & Specialized Technologies, Including Nanotechnology (9)

Author: Ms. Jasleen Kaur
Texas A&M University, United States

Mr. Navdeep Singh
India
Mr. Aniket Bire
Texas A&M University, United States

SHAPE MEMORY ALLOY-BASED SEAL ASSEMBLY FOR LEAKAGE CONTROL IN EXTREME SPACE ENVIRONMENTS

Abstract

The Artemis program aims to establish a sustainable human presence on the Moon, requiring advanced habitat technologies capable of withstanding extreme lunar environmental conditions. One of the critical challenges in extraterrestrial habitats is maintaining airtight seals to prevent leakage and ensure structural integrity under fluctuating temperatures, radiation, and mechanical stress. This research proposes a Shape Memory Alloy (SMA)-based seal assembly designed to enhance leak-tightness in lunar habitats, particularly in expandable surface structures. SMA materials, known for their ability to undergo phase transformations between martensitic and austenitic states, provide adaptive sealing by contracting or expanding in response to temperature variations. The proposed SMA ring-integrated seal assembly improves reliability by leveraging the unique thermal and mechanical properties of NiTiNb-based SMAs, which exhibit high clamping pressure, low permeability, and excellent radiation resistance. The seal assembly is designed to autonomously adjust to environmental fluctuations, ensuring consistent performance over extended mission durations. Testing of SMA-based rings in laboratory conditions has demonstrated superior leak-tightness compared to traditional metal seals, with leak rates as low as ¡10 mbar.l.s even after prolonged thermal cycling. This study outlines the operational principles, material selection, and integration of SMA rings within a NASA-inspired sealing system for lunar habitat applications. By providing enhanced resilience against temperature variations and space-induced wear, SMA-based seals can play a crucial role in long-duration lunar and Martian missions, ensuring astronaut safety and habitat sustainability.