Sept 5, 2024

Shape Memory Alloy Structures: Modeling, Simulation, and Experiments

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ABSTRACT:

Recent investigations of the physical response of shape memory alloy structures, under a wide range of thermal and mechanical loadings that link careful experiments with detailed numerical simulations are presented. First, the structure of a newly devised constitutive modeling framework describing the thermomechanical response of SMAs is discussed. The construction of the model is based on a usual flow-theory plasticity framework with kinematic hardening. One novelty of the approach is that a single transformation, i.e. yield, surface in effective stress and effective temperature space is introduced, and an associated flow rule then governs the evolution of the transformation strain and entropy. To capture the multitude of SMA behaviors, a transformation potential function is introduced in transformation strain and entropy space for the derivation of the back stresses and back temperatures that define the kinematic hardening behavior. The model is capable of capturing the asymmetries in tension versus compression for transformation strain, transformation stress, and in the hardening in tension versus compression with softening allowed in tension along with hardening in compression. The model is implemented and results are presented for the simulation of SMA strips, tubes, and cracks subjected to a wide range of thermomechanical loadings (tension, compression, bending, iso- and non-isothermal).

BIOGRAPHY:

Professor Landis has a broad range of interests in the mechanics of materials, including fracture mechanics, plasticity, micromechanics, composites, and finite element methods. He has made contributions to the constitutive modeling and fracture mechanics of ferroelectrics, ferromagnetic materials, and shape memory alloys. He has also made significant contributions to phase-field modeling of fracture where he has applied and extended this approach to dynamic crack propagation, ductile failure, hydraulic fracture, and fatigue crack growth. His work is highly collaborative and he is always looking to cooperate with other researchers both in his own department, nationally, and internationally. Professor Landis serves as an Associate Editor for the International Journal of Solids and Structures, a Regional Editor for the International Journal of Fracture, Associate Editor for the Journal of the American Ceramics Society, and in the past as Associate Editor for the Journal of Applied Mechanics. He also serves on the Editorial Board of Computational Methods in Theoretical and Applied Mechanics. Additionally, he is as a member of the U.S. National Committee for Theoretical and Applied Mechanics, and in the summer of 2022, he served as the co-Chair of the 19th U.S. National Congress on Theoretical and Applied Mechanics.