Thermo-mechanically coupled superelastic response of Nitinol

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Abstract

A three-dimensional crystal-mechanics based theory for the thermo-mechanically coupled superelastic response of polycrystalline shape-memory materials is developed and used to simulate the response of a Ti-Ni (Nitinol) shape-memory alloy. Both manifestations of superelasticity: stress-strain response at a fixed temperature, and strain-temperature response at a fixed stress have been experimentally studied. The model, when suitably numerically implemented and calibrated, is shown to accurately predict the superelastic response of the material. Also, the strain-temperature cycling experiments under different constant axial stresses are predicted with reasonable accuracy. The effects of self-heating and cooling due to the exothermic and endothermic nature of the austenite-to-martensite and martensite-to-austenite transformations were investigated by performing superelastic tension experiments at strain rates which are high enough to result in non-isothermal testing conditions. The thermo-mechanically coupled theory is able to capture the resulting *inhomogeneous* deformation associated with the nucleation and propagation of transformation fronts, and also the "apparent hardening" of the nominal stress-strain curves observed in the experiments.