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A Microstructure Based Model for Coupled Transformation and Plasticity of NiTiNb Shape Memory Alloy

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A microstructure-based constitutive model is developed for the coupled transformation, rand plastic deformation of NiTiNb shape memory alloys (SMA). It contains four stages: (1) the constitutive relationships for the individual martensite phase and austenite phase, respectively; (2) the model for a representative volume element (RVE) composed of alternatively arranged parallel lamellas of austenite and martensite; and (3) the description for the NiTi matrix by considering it as aggregates of numerous cells with different orientations and making use of the self-consistent scheme; and (4) the constitutive description of the NiTiNb SMA material composed of NiTi matrix and the β-Nb particles, making use of the Mori-Tanaka scheme. The deformation of the martensite is separated into elastic, thermal, reorientation and plastic parts, and that of the austenite is separated into elastic, thermal and plastic parts. The Tanaka's transformation rule for martensite volume fraction is modified to take into account the effect of plastic deformation. The incremental form of the constitutive model is derived, and the corresponding numerical algorithm is developed. The fundamental characteristics of the SMAs, such as pseudoelasticity, shape memory effect, the coupled transformation and plasticity and its effects, can be replicated with the model. The numerical examples are presented. The comparison between the numerical and the experimental results demonstrates the validity of the proposed model.

Keywords: NiTiNb SMA, Two-phase mixture, Microstructure; Constitutive model