THERMO-MECHANICAL MULTILINEAR SHAPE MEMORY ALLOY CONSTITUTIVE MODEL

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Modeling different behaviors of Shape Memory Alloys (SMAs) has been a great concern for researches in different fields of Engineering [1-3]. They employ different theories and approaches for this aim varying from complete theoretical models using thermodynamics and/or micromechanics formulations to experimental based models [1-3]. These models also vary on their ability to capture different behaviors associated with SMAs such as pseudoelasticity and shape memory effect by both transformation and reorientation. Another difference is the models ability to be applicable to finite element procedures and common engineering applications. SMAs also show different behaviors when subjected to different thermomechanical loadings.

The complexities of SMA behavior added to the need for a robust and finite element friendly algorithm is the reason for compromising between correctness, completeness and simplicity of the models. In this paper a model is developed in order to achieve a complete model that can be used for different simulations of high rate and low rate loadings while being multilinear and robust for using in finite element packages and common engineering applications.

The basics of the model are formulated in terms of classical thermomechanics in which the Gibbs free energy function is a function of stress, temperature and the volume fraction of detwinned martensite [3]. Defining an inelastic transformation strain and finding a proper formulation for the evolution of martensite fraction completes the model. Instead of using complicated thermodynamical equations for finding the evolution equation, here the presumed multilinear nature of the stress-strain equation forces the evolution equation. With some rational simplifications, the response for the adiabatic simulations can also be predicted simply by the proposed model.

In brief, the proposed model captures most behaviors of SMAs under different mechanical loading conditions with simple and robust formulations which make it appropriate for use in finite element procedures. Comparison of the model with other models and verification of the results with experimental data are also included and show good agreement.

References:

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