

Robustness and efficiency of integration algorithms for a 3D finite strain SMA constitutive model

J. Arghavani, F. Auricchio, R. Naghdabadi, A. Reali

Most devices based on shape memory alloys experience large rotations and moderate or finite strains. This motivates the development of finite-strain constitutive models together with the appropriate computational counterparts. To this end, in the present work a three-dimensional finite-strain phenomenological constitutive model is investigated and a robust and efficient integration algorithm is proposed. Properly defining the variables, extensively used regularization schemes are avoided and a nucleation-completion criterion is defined. In addition, introducing a logarithmic mapping, a new form of time-discrete equations is proposed. The solution algorithm as well as a suitable initial guess for the resultant nonlinear equations are also discussed. Numerical tests are performed to show robustness as well as efficiency of the proposed integration algorithm. Moreover, its implementation within a user-defined subroutine UMAT in the commercial nonlinear finite element software ABAQUS makes also possible the solution of a variety of boundary value problems. The obtained results show the efficiency and robustness of the proposed approach and confirm the improved efficiency (in terms of solution CPU time) when a nucleation-completion criterion is used instead of regularization schemes, as well as when a logarithmic mapping is used for the time-discrete evolution equation instead of an exponential mapping.