Dissipation Rate Considerations for Continuum Slip Crystal Plasticity

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Abstract

The requirement of a non-negative dissipation rate for all possible deformation histories is generally imposed on continuum slip crystal plasticity constitutive relations. This is a constraint analogous to the Coleman–Noll postulate (Arch. Ration. Mech. Anal., 13, 167, 1964) that the Clausius–Duhem inequality needs to be satisfied for all possible deformation histories. The physical basis for the Clausius–Duhem inequality arises as a statistical limit for a large number of discrete events for a long time and is not a fundamental physical requirement for individual events that take place for a short time. Consequences of considering dissipation rate in formulating crystal plasticity constitutive relation are illustrated for: (i) the form of constitutive relation that emerges for a single crystal continuum slip plasticity constitutive framework that accounts for elastic lattice curvature changes as well as elastic lattice straining and (ii) a conventional (size-independent) continuum slip crystal plasticity constitutive relation that incorporates a non-Schmid term into the plastic flow rule so that a non-negative dissipation rate for all possible deformation histories is not guaranteed and the consequences, if any, of a negative plastic dissipation rate are explored.

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