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A Thermodynamically Consistent Framework to Derive Local/Nonlocal Generalized Nonassociative Plasticity/Viscoplasticity Theories

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ABSTRACT

We present a rigorous and consistent thermodynamic-based approach to derive generalized nonassociative rate-independent and rate-dependent plasticity theories. It is demonstrated that the nonassociative plasticity theories are a straightforward consequence of the principle of virtual power. Besides, the relationship between the plastic potential function and yield function is established on the basis of the principle of virtual power. All thermodynamic conjugate forces are decomposed into two parts referred to as the energetic and dissipative components. The energetic part is derived from the Helmholtz free energy while the dissipative component is derived from the rate of the dissipated energy by postulating the principle of maximum dissipation. It is also shown that the nonlocality energy residual, arising from plastic strain gradients, has two components: namely, the energetic nonlocality energy residual, which is stored at the interfaces; and the dissipative nonlocality energy residual, which is dissipated through the interfaces. Finally, several examples are provided focusing on the derivation of associative/nonassociative local/nonlocal plasticity and viscoplasticity models based on the presented thermodynamic framework.

Keywords: Gradient plasticity; Nonassociative plasticity; Interfaces; Maximum energy dissipation; Nonlocal yield surface; Nonlocal energy residual.

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