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A peridynamic model for plasticity: micro-inertia based flow rule, entropy equivalence and localization residuals

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Abstract

This article presents a non-ordinary state-based peridynamic (PD) model for thermo-visco-plasticity that incorporates a micro-inertia driven dynamic flow rule. In addition to the three displacement degrees of freedom, the model assigns, to each particle, an internal degree of freedom, namely, the equivalent plastic strain. The flow rule itself is in the form of an integro-differential micro-force balance, written in terms of appropriate PD states associated with micro-stresses corresponding to the internal degree of freedom. An equation for entropy balance, adapted to the PD setup, is also proposed. Along with the internal energy equivalence, we exploit a notion of equivalence of the local entropy production for the constitutive modelling of the force states. As we also demonstrate, the PD model naturally accounts for the localization residual terms in the local balances for internal energy and entropy, originally conceived of by Edelen and co-workers nearly half a century ago as a source of nonlocal interaction. The model is numerically implemented for the problem of impact between two 4340 steel plates, and the results show that the model provides information on nontrivial effects of micro-inertia on the plastic flow and temperature generation. By incorporating a classical damage model in the PD set-up, we also discuss an