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A semi-infinite edge dislocation model for the proportionality limit stress of metals under high strain rate. (English) Zbl 1479.74018

Comput. Mech. 68, No. 3, 545-565 (2021).

Summary: Micromechanics of strain rate dependent elastic response, within the proportionality limit in metals is investigated, on the basis of dislocation kinetics. It is postulated that, the strain rate dependence of proportionality limit stress is dominated by inertia of dislocations, over drag controlled mechanisms. Subsequently, kinetic energy of accelerating edge dislocation at its incipient motion, is expressed. The proposed, inertia-dominated model is non dissipative in nature when compared with that of Frank-Read dislocation nucleation-based model and dislocation-drag mechanism-based model at high strain rates. Using Hamiltonian formalism, a new rate dependent slip criterion with corresponding threshold shear stress is derived. Experimental data on FCC samples, Aluminium-1100-0 and Oxygen free Copper; and BCC samples, pure Iron and mild steel, within a benchmark strain rate of 10^4 s^{-1}, are used to validate the model prediction. Reported theory on dislocation drag controlled model is compared with the proposed inertia-based theory, using published experimental data.

MSC:

74C10	Small-strain, rate-dependent theories of plasticity (including theories of viscoplasticity)
74A60	Micromechanical theories

Keywords:

energy balance method; strengthening mechanism; dislocation inertia; strain rate-dependent material; dislocation drag; slip criterion

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