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ABSTRACT

Kinematic hardening in metals is widely correlated with various cyclic plastic behaviors. Inspired by the classical dislocation pile-up model and the finite potential well concept in quantum mechanics, a hypothetical dislocation well model is proposed to describe dislocation behavior on a slip plane. In this model, dislocations are also generated in pairs from the source, gliding along opposite directions and interacting with well sides, resulting in impeded dislocations forming kinematic hardening and tunneling dislocations passing through the well. Given the point symmetries of dislocation generation at the source, interaction with the well sides and annihilation in the sink, signed scalars are imported to quantify the impeded and tunneling dislocations and their corresponding shear strains. A common power form rule for tunneling shear strain and a simple linear hardening law for impeded shear strain are introduced for validation. By assigning additional axisymmetry in the model, the kinematic hardening response is proven to be consistent with the Ohno-Wang models under uniaxial loading. Moreover, the multiple discrete kinematic hardening components are expressed in this model by decomposing the plastic strain into several parts with different tunneling attributes but identical kinematic hardening moduli, and can be further extended into a continuous distribution density form in the total shear strain components. Apart from the path-independent constant density distribution in the total shear strain components, dislocation well sides as stacks in which shear strain components can be stored in order and recovered in the reverse order are also introduced. Shakedown behaviors with constant distribution density in total shear strain components and dislocation well sides or source as stacks, are explored in detail, respectively. In addition, a general non-axisymmetric dislocation well is also proposed and shakedown behavior under the same situations is exploited accordingly.