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INVESTIGATION OF COMPLEX AND CYCLIC LOADING AND DAMAGE ACCUMULATIONS IN MULTILEVEL POLYCRYSTAL MODELS

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Changes in the physical and mechanical properties of the specimen during deformation is a consequence of a substantial restructuring of the micro- and mesostructure of the material. Mainly it is a consequence of a significant evolution of the dislocation (wider - defective) structure of the material [1]. It is impossible to describe such processes without studying and establishing appropriate mathematical models that explicitly take into account the physical causes of the material's microstructure evolution at large deformations. Directly into the structure of crystal plasticity relations this description of the microstructure evolution is introduced through specific relationships that determine the change of the critical shear stress on the slip systems on a set of parameters defined on the basis of physical analysis (shears, temperature, stacking fault energy etc.), which are commonly called hardening law [2-4]. This explains the considerable attention in crystal plasticity, which is paid to the modification of hardening law, in particular - in connection with the new experimental data obtained with the use of high-resolution equipment, this is shown in [5].

The aim is to study the effects produced by polycrystalline representative macro volume of material under complex and cyclic loading (and the transition from one to another type of loading) as a consequence of changes occurring at the level of the dislocation, and attempt to modify the laws hardening so way that they can physically describe these changes and effects. In particular, the unresolved issue is to justify and describe the known experimental effects, such as the dependence of additional cyclic hardening of the rank of loading disproportionality, cyclic softening by the transition from non-proportional to proportional loading, transverse hardening.

The correct description of hardening, which is an essential mechanism of the plastic deformation, allows to obtain dependence the numerical experiments which corresponding experiments, on the other hand, in the hardening laws it is inherent the description of the microstructure of the material and the laws of its evolution.

Hardening is divided into "non-oriented" and "oriented" parts. The first one describes the hardening regardless of the direction of deformation (under this definition, processes such as the formation of the intersection of dislocations, plaits, braids, dislocation barriers), and a hardening increases the critical shear stress at once on many slip systems (or even all at once). The second is related to the accumulation of elastic energy to "pursed dislocations" (at different barrier) and this energy may be (fully or partially) released at the change the direction of deformation. The second type, in general, can be described by the kinematic hardening, or due to simultaneous changes in the critical shear stress on the opposite slip systems.

By using the formalism of constitutive models with internal variables and two-level mathematical model of polycrystals inelastic deformation, based on the crystal elastoviscoplastic model at meso level, we received both general and particular form of hardening laws of mono- and polycrystalline, allows to describe the formation and destruction of dislocation barriers, the annihilation of dislocations (and so describes Bauschinger effect), and additional hardening, resulting from the interaction of intragranular and grain boundary dislocations [6].

The analysis of the possible mechanisms of interaction between carriers and the plastic deformation of the crystal lattice defects is executed; hardening laws that discovers a good agreement with experimental data are proposed. We also introduce the parameters characterizing the accumulation of damage and formulate fracture criterion using methodology of multilevel modelling.

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