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SIMULATION OF PLASTIC BEHAVIOUR OF FCC METALS ACCOUNTING FOR LATICE ORIENTATION

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ABSTRACT

Plastic deformation causes permanent changes in the shape of the object due to the applied external loads. Two main mechanisms are considered during deformation: slip or twinning or their combination. The slip process depends on gliding of parts of crystal lattices along each others. Since this requires the least amount of energy, the slip occurs in directions, in which the atoms are most closely packed. Combination of planes and directions of gliding are called slip system. The main goal of this work is identification of active slip systems during subsequnet stages of deformation and analysis of its influence on material behavior. Prediction of deformation textures, stress-strain curves and distribution of the stored energy is another goal of the research. Particular attention is put on investigation of fcc metals with medium and high Stacking Fault Energy.
Different approaches to modeling crystallograpic aspects of deformation can be identified in literature e.g. conventional method (grains are descibed by various flow curves) or single crystal plasticity models [1,2,3,4]. The crystal plasticity Leffers-Wierzbanowski (LW) model was selected and implemented in this work.

LEFFERS-WIERZBANOWSKI MODEL

In the current approach at the slip plane level, the plastic strain is modeled by a crystallographic gliding on slip systems. Each slip system is defined by a unit vector normal to the slip plane *n* and a unit vector *m* indicating the slip direction. It is assumed, that the crystallographic gliding process occurs when the Schmid law is fulfilled. In other words the slip process in crystals occurs on any particular slip system, when the resolved shear stress on the slip plane and slip direction reach a critical value. This critical value depends on the hardening state of the system. The resolved shear stress tcr is defined as the projection of the stress tensor on the considered slip system. If the stress state is specified by the tensor σ_{ij}, then the Schmid law is expressed as [5]:

$$\tau = m_i n_j \sigma_{ij} \geq \tau_{cr} \quad (1)$$

During the process of crystallographic gliding, the interactions between dislocations lead to an increase of the critical shear stress of each slip system. The hardening on slip system i depends on the slip of all other active systems j. Based on the presented above information the strain and rotation of grain are calculated as symmetric and anti-symmetric parts of strain gradient tensor.

The LW algorithm [6] that was implemented into the comercial FE Forge 3 software is presented in Fig. 1. The practical applications of the model are e.g. prediction of deformation textures, stress-strain curves and distribution of the stored energy as well as the interpretation of residual stress measurement by diffraction technique.

Results of simulations of the channel die compression test for the monocrystline as weel as bicrystaline sample are shown and are disscused in the paper. It is assumed that each grain in the model is defined by different crystallographic orientation. The numerical investigation starts with only one active slip system. Further on twelve slip systems are enebaled and its influence on material behavior are analysed to explain differences in behavior of materials with various number of grains and slip systems.

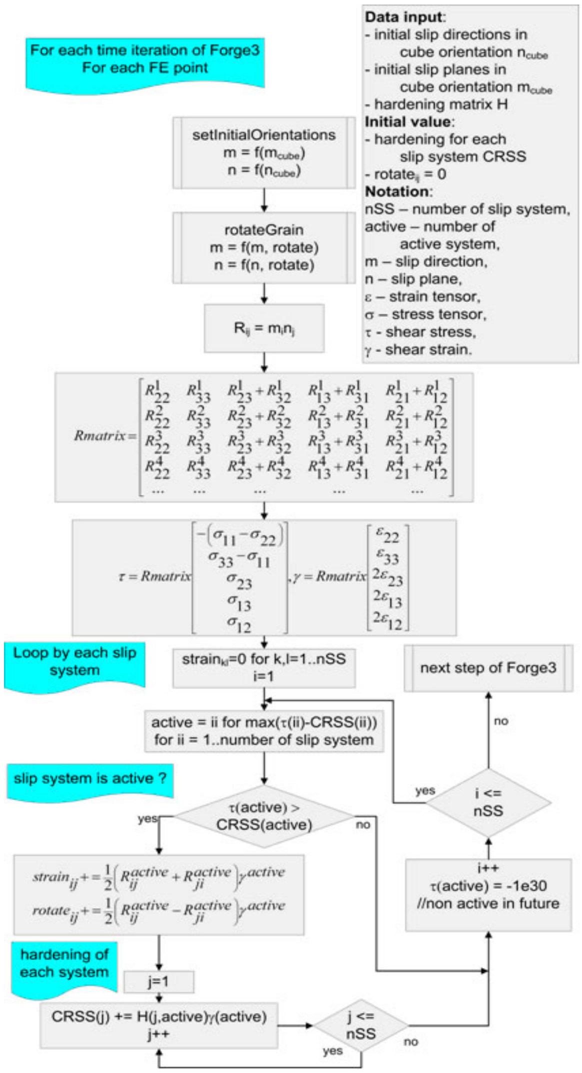

Figure 1. Algorithm of Leffers-Wierzbanowski model.

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