THE INFLUENCE OF WORK HARDENING AND SOFTENING ON THE SPACE-TIME CHARACTER OF SINGLE SLIP DEFORMATION - A COMPUTER SIMULATION

B. Sprušil

Faculty of Mathematics and Physics, Charles University, Ke Karlovu 5, 121 16 Praha 2, Czechoslovakia

H.-U. Fritsch, B. L. Mordike

Institut für Werkstoffkunde und Werkstofftechnik der TU Clausthal, Agricolastr. 2,
3392 Clausthal-Zellerfeld, BRD

Work hardening and work softening processes during single slip deformation are simulated by computer modelling and presented in the form of space-time diagrams.

During the past three years we were concerned with the analysis of slip line patterns on the surface of deformed single crystals [1] and with the computer simulation of the development of such patterns in the course of single slip deformation [2]. Recently we have extended these calculations by taking into account the work hardening and softening processes and by visualising the course of the deformation by means of graphs used in the theory of cellular automata. This is a preliminary report on these calculations, which will be published in their full extent elsewhere.

The single slip deformation of a single crystal has a two-fold quantum character, which is given by the minimum distance between two slip planes and the minimum slip step height on the crystal surface. This was taken into account by representing the single crystal by a stack of \(N_p\) slip plates which are allowed to move one past another by a minimum slip distance — so called elemental slip event (ESE). For the sake of simplicity the slip plates were assumed to have a constant inclination of 45 degrees to the crystal axis (45D-crystal). It was further assumed that the time can be measured in units of number of attempts to produce an ESE. The process of deformation was simulated in the following way: at each time step a randomly chosen slip plate was checked for its ability to slip, which was characterised by the

Fig. 1. A space-time map with a slip plate \(E\) slipped at time \(t = 1\) and its action field.
value of its slip probability. At the beginning of the experiment (at \( t = 0 \)) all slip plates were assumed to be in a "ground state" with slip probability \( \alpha \). Suppose that at \( t = 1 \) the first attempt to produce an ESE was successful on plate \( E \) in fig. 1. Then it is considered that not only on this plate but also on neighbouring plates on either side the slip probability is changed to \( \beta \) for next \( N_T \) attempts; just two possible values of slip probability, \( \alpha \) and \( \beta \), were considered. An "action field" of rectangular form with sides \( N_X \) and \( N_T \) is thus defined which influences future events and can be represented schematically, fig. 1. Both \( \alpha \) and \( \beta \) are considered to be independent of time. For \( \alpha > \beta \) the slip event causes work hardening whereas for \( \alpha < \beta \) work softening takes place.

The most complete visual information on the space-time character of the deformation process is given by a fig. 1 — type map on which every ESE is marked by a dot with the coordinates slip plate number and attempt number. Such maps are similar to those used in the theory of cellular automata [3] and therefore we call them CA-diagrams. By ascribing to each row of this diagram the value 0 or 1 to show whether slip took place or not at that attempt and by summing up these values the time dependence of the slip events can be obtained. This is at each time proportional to the instantaneous total elongation or to the relative deformation \( R_D \). The graph of this time dependence is termed in the following the creep curve. Due to the quantum character of slip the creep curve should in principle consist of steps corresponding to one ESE; for the sake of simplicity these elemental steps will be neglected in the following description.

Fig. 2. The CA-diagram (a) and the creep curve (b) for deformation inhomogeneous in time.
Fig. 3. The CA-diagram (a) and the creep curve (b) for deformation inhomogeneous in space.