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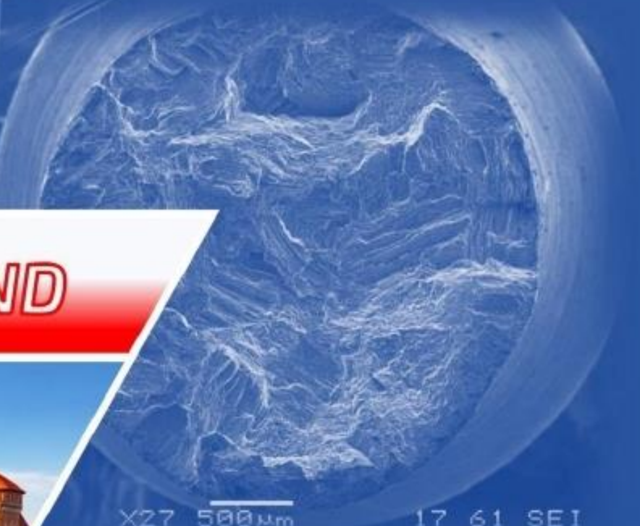
BOOK OF ABSTRACTS



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SHEAR BANDING - A KEY MECHANISM CONTROLLING VISCOPLASTIC FLOW. II. NUMERICAL SIMULATIONS OF SOME EXPERIMENTALLY PERFORMED PROCESSES

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1. Introduction

The metallic materials undergo various manufacturing operations such as forming, forging, extrusion, machining, and cold working. Experimental investigations of the behaviour of high strength metallic materials under quasistatic and dynamic loading conditions related to microscopic observations show that in many cases, the dominant mechanism of plastic strain is multiscale development of shear deformation modes–called shear banding [1]. The Viscoplasticity model with the overstress function proposed earlier by Perzyna [2] was extended to describe the new mechanism of inelastic deformation [1, 3, 4].

The paper aims to study the application of the new description of viscoplastic deformation, which accounts for the observed shear banding phenomena. The numerical simulations of the deformation processes of metallic specimens in the channel-die test are performed.

2. The channel-die test

The compressive loading in the channel-die test was carried on the OFHC copper at strain rates of 10^{-3} s^{-1} in the loading direction and described by Bronkhorst et al. [5], Kalidindi et al. [6]. In the experiment, all contacting surfaces of the specimen and the die were ground smooth and well lubricated. Two types of sample shapes were tested. One type of specimen was machined in a rectangular block of dimensions 9.52 mm in height (loading direction), 26.4 mm and 23.5 mm in the other two directions [5]. The another, specimen was machined in the form of a prism that had the following initial dimensions: height (compression direction), 13.97 mm; length (flow direction), 23.5 mm; width (constrained direction), 26.4 mm. Plane strain can be applied almost perfectly, but friction, which extends to the lateral faces of the sample, is likely to play a more critical role. Thin Teflon films or "classical" lubricants such as graphite or boron nitride powders can lubricate the sample surfaces, leading to a quasi-zero friction coefficient.

The paper aims to interpret the channel-die compression tests at room temperature, where friction effects can be neglected. Isotropic viscoplastic incompressible materials submitted to large strains are considered. The constitutive viscoplastic model accounting for micro-shear bands of OFHC copper is applied. The compression test is carried out at a constant equivalent strain rate of 10^{-3} s^{-1}. A power law describes the flow stress of the material in the overstress function Perzyna type viscoplastic equation. The material parameters obtained for the annealed OFHC copper used in Kalidindi et al. [6] experiments are applied in the simulation.

3. Numerical simulations and identification of the model parameters

The ABAQUS software performed the numerical simulations of the channel-die quasistatic and dynamic compression tests. Due to the symmetry of the experimental setup, only half of the geometry was modelled. The vertical plane (walls of the channel) and one horizontal plane (bottom

of the channel) represent the channel-die device. These two planes are embedded by their reference nodes, whose degree of freedom is set to zero. The tool is represented by an additional horizontal plane whose reference node controls the sample's nominal strain and nominal strain rate. The planes representing the walls of the channel and the tool are rigid since the elastic deformation of the mechanical device can be neglected. The specimen is meshed using C3D8R elements (8 integration points). The power hardening law described the material's stress-strain curve [1]. A global surface contact was defined with the option available in the ABAQUS. The action of the tools is simulated by the definition of the contact pairs between the specimen surface and the vertical and horizontal surfaces. The friction coefficient was chosen equal to zero for all the friction surfaces, although a specific coefficient can be applied to the various boundaries of the specimen.
The model was tested and validated for the homogeneous case (no friction on all the surfaces) and the conditions that lead to symmetric law (no friction on the lateral surfaces and friction on the horizontal surfaces). This result indicates and justifies the possible assumption of local plane strain. The basic idea of the identification procedure was to determine all material constants of the shear banding influence function using the inverse solution of the boundary value problem simulating the compression test process numerically. The least-squares method requires the residual sum in nominal stress between the experimental observations, σ_{Exp}, and model results, σ_{Model}, to be minimised. Finally, it implies that the proposed model of rate-dependent plasticity can be entirely calibrated by minimising the residual function $F(\varepsilon_{eqv}^{pl})$, which refers to the residual of the constitutive model and the experimental data as a function of equivalent plastic strain ε_{eqv}^{pl} .

4. Conclusions

This paper presents the description of the rate-dependent plastic behaviour of polycrystalline copper OFHC and the new feature of our proposition to account for shear banding. The multiscale shear band formation mechanisms are responsible for accommodating the inelastic deformation. Therefore, the proposed description can also be applied to other ufg, nc-metals, and hard-deformable materials. Finally, the identification of constitutive relations of viscoplastic flow was made for *fcc* metal. Finally, the derived constitutive equations will be applied to solve an inverse problem and the verification behaviour of such materials using other independent experimental tests.

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