EXPERIMENTAL INVESTIGATIONS OF THE INFLUENCE OF MODERATE STRAINS AND STRAIN RATES ON THE YIELD SURFACE OF OFHC COPPER

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The aim of the work is to investigate the influence of moderate strains and strain rates of the range of $10^{-4} \le \dot{\varepsilon} \le 10^{-2}$ s^{-1} on the evolution of the yield limit surface. The experimental investigations were performed on the as received oxygen free high conductivity (OFHC) Copper. The specimens were machined from the commercially available round bars of the diameter 12mm. Four kinds of experimental tests were performed: tensile test for smooth round specimens and compression test of smooth cylinders as well as biaxial compression test using cube specimens and double shear tests of cuboid specimens with machined narrow shear zones. The elaborated experimental data show that the investigated material reveals a slight pressure sensitivity showing small strength differential effect of the order of $\kappa = k_C / k_T \approx\sim 1{,}1$ and certain influence of initial anisotropy, which is confirmed by the investigation of texture pole figures. The effect of initial anisotropy manifests itself in the observed deviation from the Huber-Mises yield condition. The deviation was observed in the confrontation of experimental data using limit values in shear test and biaxial compression test.

To find more adequate description of experimental results the Burzyński yield criterion was applied, [1]. The criterion is assumed for isotropic solids and the effects of initial anisotropy are captured by means of certain correction factor λ. The meaning of this factor can be explained by means of the relation between the yield limits obtained in the tensile k_T, compression k_C and shear k_S tests, respectively [1]:

$$\sqrt{3}\, k_S^2 = \frac{k_T k_C}{2(1+\lambda)} \quad (1)$$

Observe that for ideal isotropy with symmetry of elastic range, $k_T = k_C = k$ the factor λ is equal 0,5 and the above relation takes form $\sqrt{3}\, k_S = k$ known from the Huber-Mises condition. In general, the Burzyński factor λ takes values in the range $0 < \lambda < 1$. The yield condition for isotropic solids accounting for Burzyński's correction can be expressed in the principal stress axes in the following form [1], and $\sigma_1 \ge \sigma_2 \ge \sigma_3$:

$$(1-\lambda)(\sigma_2-\sigma_3)^2 + \lambda(\sigma_3-\sigma_1)^2 + (1-\lambda)(\sigma_1-\sigma_2)^2 + (k_C-k_T)(\sigma_1+\sigma_2+\sigma_3) = k_C k_T, \quad (2)$$

The following states of stress were considered with use of the performed experimental tests:

1. Uniaxial tension: $\sigma_1 = k_T, \quad \sigma_2 = 0, \quad \sigma_3 = 0$.
2. Uniaxial compression: $\sigma_1 = 0, \quad \sigma_2 = 0, \quad \sigma_3 = -k_C$.
3. Pure shear: $\sigma_1 = k_S, \quad \sigma_2 = 0, \quad \sigma_3 = -k_S$.
4. Biaxial compression: $\sigma_1 = 0, \quad \sigma_2 = -\nu k_{CC}, \quad \sigma_3 = -k_{CC}$

A representation of experimental points in the plane (σ_{eq},σ_m) together with yield curves of corrected Burzynski (1) and Huber-Mises (2) is displayed below

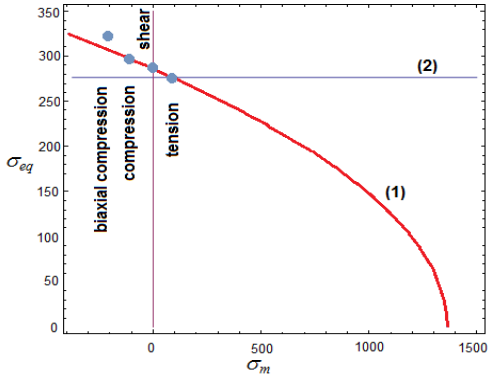

Fig 1. Results of experiments and yield curves in the (σ_{eq},σ_m) plane.

Another example of yield limit curves for OHFC Cu in the plane state of stress (σ_1,σ_3) and (σ_2,σ_3) for strain rate 0.001 s^{-1} and strain level 0.002 is presented below.

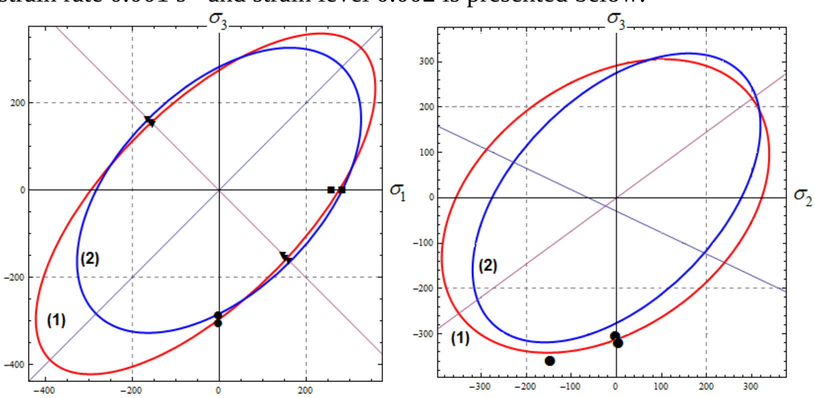

Fig 2. Results of experiments and yield curves in the planes (σ_1,σ_3) and (σ_2,σ_3).

It is visible that the corrected Burzyński criterion appears more adequate in comparison with the classical Huber-Mises condition.

The study of strain-rate sensitivity shows also that the yield surface increases uniformly with increase of strain-rate. In conclusions, the relation with the studied in the literature effect of the third invariant of the stress deviator (Lode angle), [3-6] is also discussed.

References:

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