The Construction of the Deformation Diagrams of Metals and Alloys at Impact Compression of Tablet Specimens with Friction Forces Consideration

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The influence of friction forces on the dynamic deformation of elastoviscoplastic tablet specimens was numerically and experimentally investigated. The main dependencies of their shape changing for metals and alloys have been established. A criterion of the shape changing of tablet specimens is proposed. A new method for identifying of the coefficients of dry friction at contact surfaces, depending on shape changing of the tablet specimens, based on numerical modeling of an axisymmetric dynamic problem and a rapidly convergent method of successive approximations was developed. The division of the two-parameter identification problem into two problems of one-parameter parameterization is theoretically justified with a high degree of reliability: the problem of determining of the friction coefficient and the problem of construction of the true diagram of dynamic deformation in this experiment with the friction coefficient found earlier. As a result, the dynamic deformation diagrams with frictional forces and radial inertia consideration are constructed using the iterative method. In known approximation methods of construction of the deformation diagrams with frictional forces and radial inertia consideration, friction coefficients are assumed to be known, whereas methods for their determination in experiments with impact compression are practically unavailable.

Key words: true deformation diagram, friction coefficient, friction force, edge effect, impact compression of tablet specimens, shape changing of tablet specimens, numerical simulation.
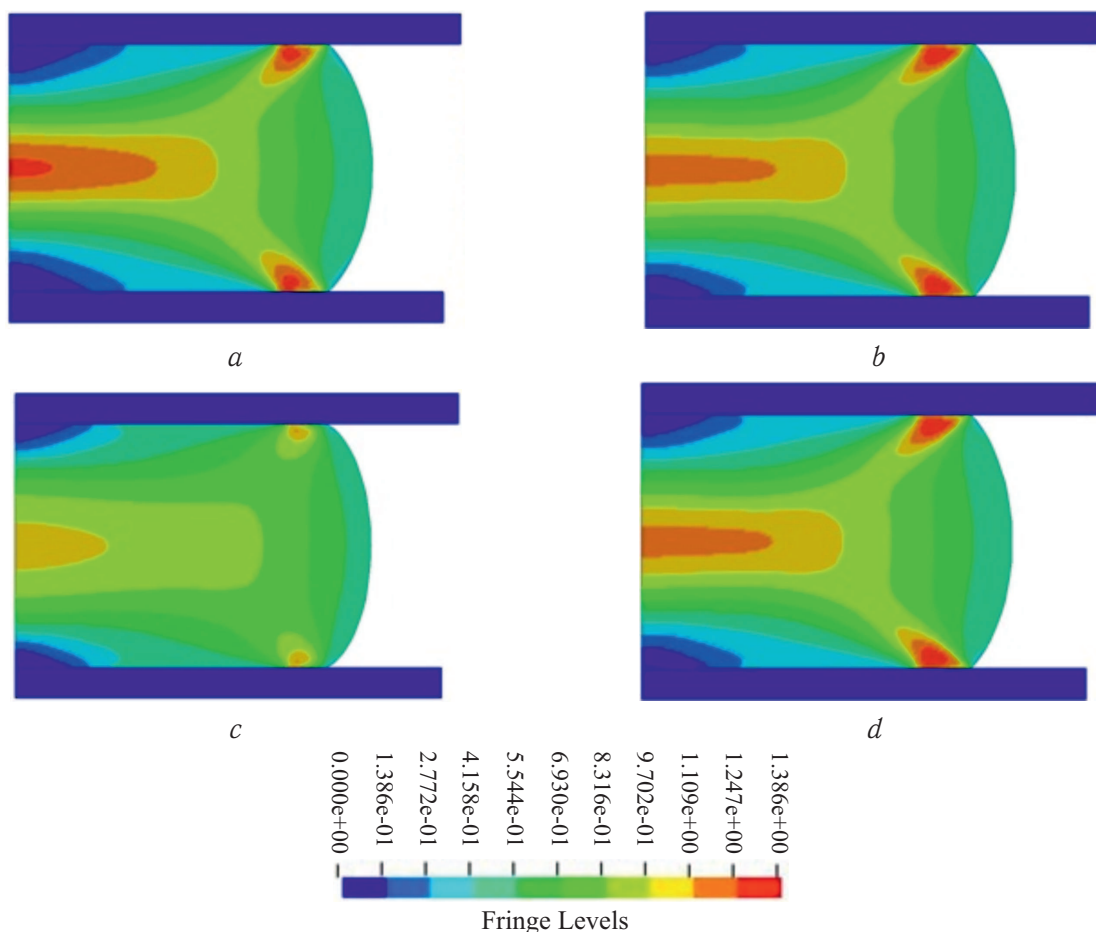
Fig. 1. The shape changing of the rablet specimens ($L_0/R_0 = 2$) at settlement $u/L_0 = = 0.5$ and their corresponding distributions of true strain intensities for steels 09G2S (*a*), 12KH18N10T (*b*) and plumbum at axial strain rates $\dot{\varepsilon}_0 = 500\,1/c$ (*c*) and $\dot{\varepsilon}_0 = 1000\,1/c$ (*d*)
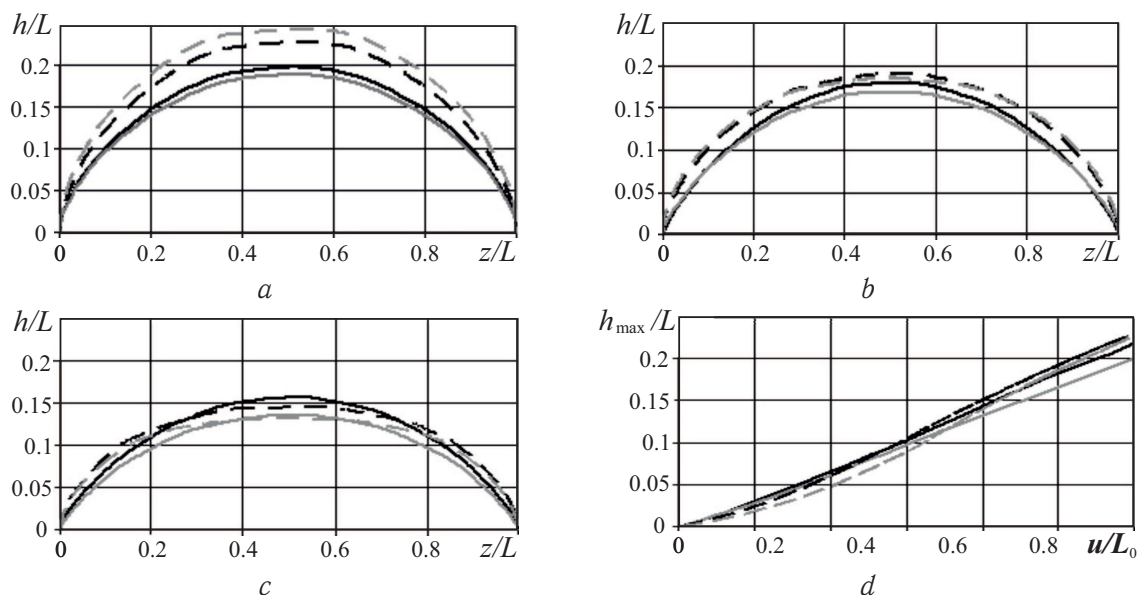

Fig. 2. The shape changing of the lateral surface of the specimens (arches) $L_0/R_0 = 1$ (*a*), $L_0/R_0 = 2$ (*b*) and $L_0/R_0 = 3$ (*c*) from the height of the specimen z/L with conditional strain of the draft 50% and change in the maximum arch height $L_0/R_0 = 2$ from tablet specimen settlement u/L_0 (*d*) at a coefficient of riction of 0.3 for steels 09G2S, 12KH18N10T (solid lines, black and gray respectively) and plumbum at $\dot{\varepsilon}_0 = 500\,1/s$ and $\dot{\varepsilon}_0 = 1000\,1/s$ (dashed lines, black and gray respectively)
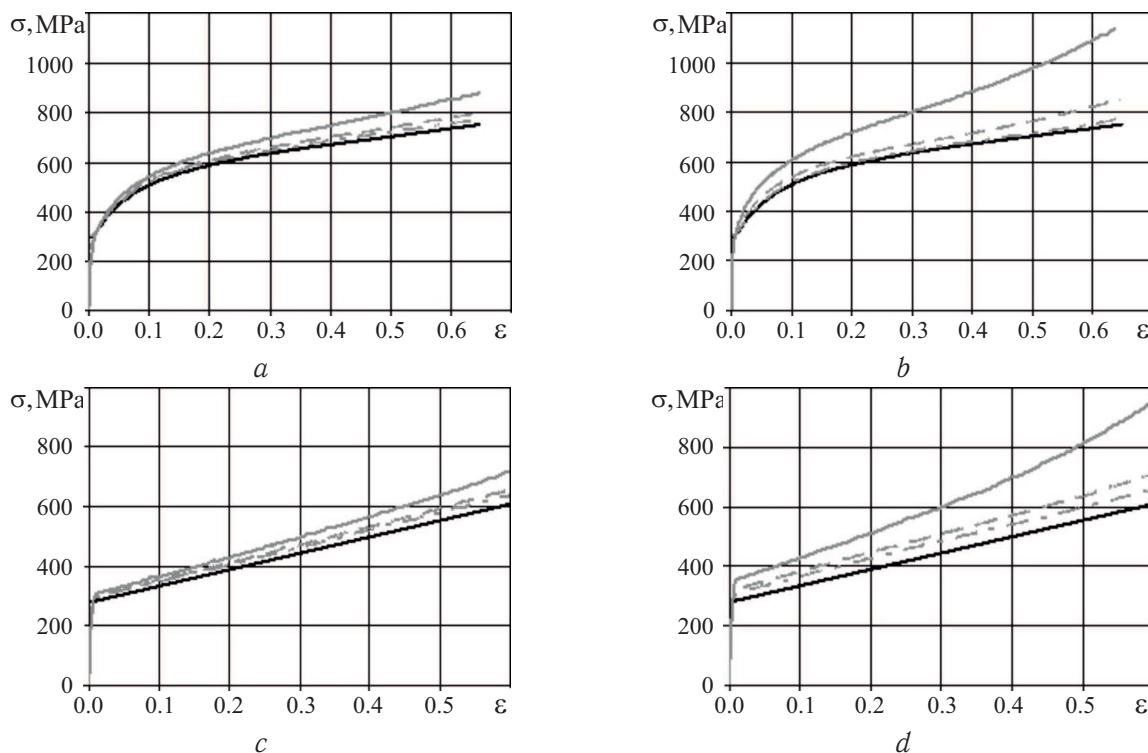
Fig. 3. The deformation diagrams constructed with and without friction forces consideration for steel 09G2S (*a, b*) and plumbum (*c, d*) at friction coefficients 0.1 (*a, c*) and 0.3 (*b, d*): solid black lines — true deformation diagrams, gray solid lines, dashed lines and dash-dot lines — diagrams obtained without friction force consideration for the specimens $L_0/R_0 = 1$, $L_0/R_0 = 2$ and $L_0/R_0 = 3$ respectively
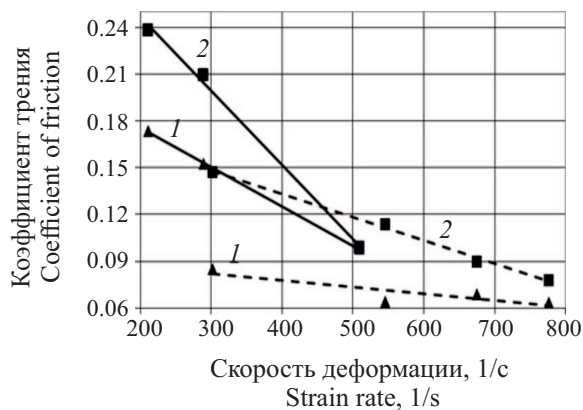

Fig. 4. The change in friction coefficients from the strain rate $\dot{\varepsilon} = \dot{u}/L$ for steel 09G2S (dashed lines) and plumbum (solid lines): *1* — on the lower surface, *2* — on the upper surface
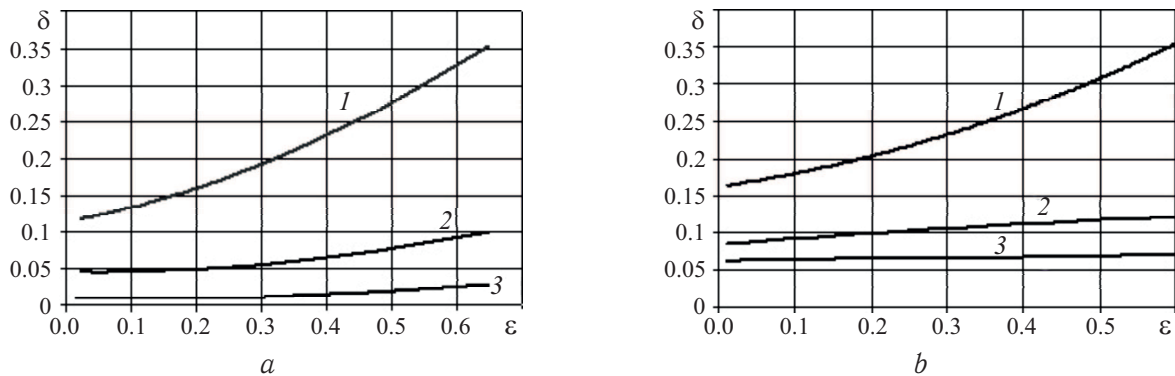
Fig. 5. Relative errors δ in the definition of deformation diagrams without friction forces consideration on the degree of deformation ε at a friction coefficient of 0.2 and the specimens size $L_0/R_0 = 1$, $L_0/R_0 = 2$ and $L_0/R_0 = 3$ (curves *1, 2, 3*, respectively) for steel 09G2S (*a*) and plumbum at the strain rate $\dot{\varepsilon} = \dot{u}/L = 500$ 1/s (*b*)

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