UDC 531

TO THE QUESTION OF THE MECHANICS OF THE PROCESSES OF WORKING OF MATERIALS BY PRESSURE IN THE STATIONARY DEFORMATION ZONES

Dobrov I.V., Semichev A.V., Morozenko O.P., Koptilyy O.V.
National Metallurgical Academy of Ukraine, Dnipro, Ukraine

Abstract. *A mechanical model of the deformation zone is developed in the form of colored magnetized metal balls moving in a geometrically similar model of monolithic drawing that provides visualization of local plastic deformations depending on the technological parameters of the drawing process. This model allows broadening our understanding about the mechanics of the process of plastic deformation. It is determined that in any type of working metals by pressure during the stable process of deformation of the stock in the stationary deformation zone «fresh layers of the stock material» come out from the inside of the deformation zone to the contact surface of the tool and stock thereby causing uneven wear of the outer surface of the finished product at constant values of the contact pressure, the coefficient of external friction and the relative sliding speed respectively to the instrument.*
Key words: *plastic deformation, stock, monolithic drawing, drawing speed, deformation speed, mechanical model.*

Development and improvement of methods of calculation and analysis of working metals by pressure (WMP) determines further improvement the mathematical models [1,2] describing the processes of deformation of the material by the mathematical formulas including formal methods of solution of the received equations and other various deformation models of materials [1-4].

Objective. Develop and explore the mechanical model of local deformations of the stock during drawing in monolithic tool for broadening our understanding about the mechanics of the process of WMP in stationary deformation zone [1] based on the modern evolution models[2] of plastic material deformation.

Research. The nature of the movement of the particles of the material of the stock *1* in the monolithic tool *2* is presented in [5] in the form of Fig. 1, *a* (the upper not darkened half of Fig. 1, *a*). It shows the change in shape and linear dimensions of cells and lines of a square coordinate grid, plotted on the symmetry plane of the drawn profile [5]. The lower darkened half of Fig. 1, *a* shows the change

[1] THE DEFORMATION ZONE WITH THE DIMENSIONS WHICH DOES NOT CHANGE DURING DEFORMATION OF THE STOCK (DRAWING, PRESSING, ROLLING, ETC.).
[2] The evolutionary model allows us to view the process in development. [1].

in the trajectories of the centers of mass (*c.m.*) of the unit cells of the coordinate grid before entering the tool ($a_0b_0c_0d_0$), inside the tool ($abcd$) and at the exit of the tool ($a_1b_1c_1d_1$). Comparison of the upper and lower halves in the Fig. 1, *a* shows that the nature of the movement of the particles of the stock material in the deformation zone (the upper half of Fig. 1, *a*) can, in the first approximation, show the nature of the displacement of the centers of masses of these particles (the lower half of Fig. 1, *a*). Thus, the process of plastic deformation of the elementary volume of the stock material (unit thickness) in the section of the deformation zone can be represented as the displacement of a non-deformable point of the center of mass of the elementary volume and the plastic deformation of the material of this elementary volume with respect to the position of its center of mass [6,7]. In its turn, the change in the trajectory of non-deformable centers of mass of elementary volumes in the deformation zones can be filmed using the digital camera (Fig. 1, *b-d*) if the deformation zone is represented geometrically by a similar model of the cross section of the deformation zone *2* inside of which colored magnetized metal balls *1* and $1^{/}$ are located. The diameters (d_b) are much smaller than the output cross section of the deformation zone of the model ($d_b << h_1$) [8]. Fig. 1, *b* shows the position of the vertical section of the stock material in the form of darkened balls $1^{/}$ at the entrance to the model of the deformation zone *2*.

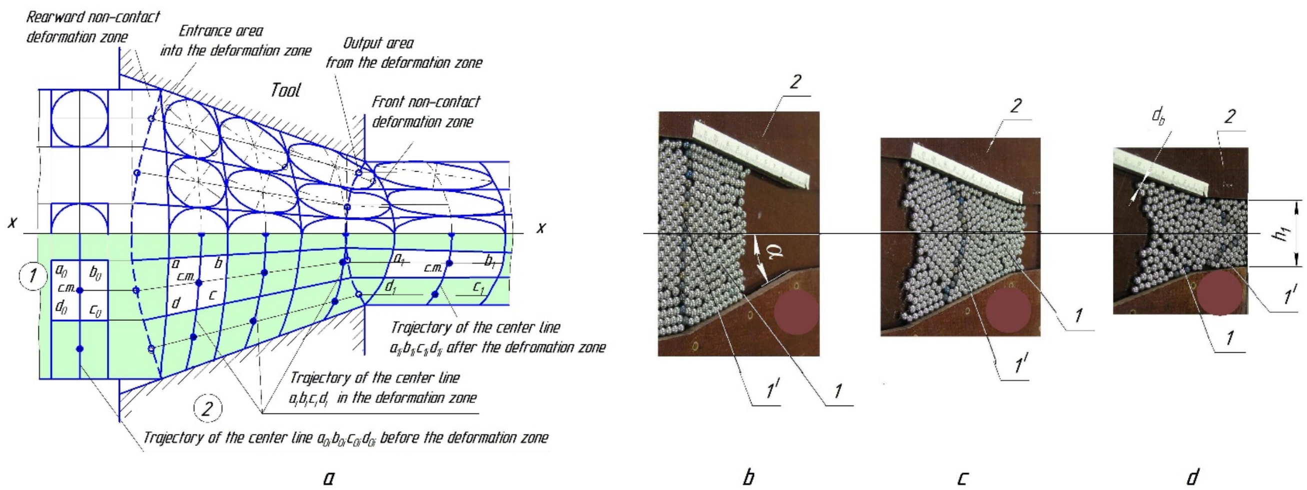

Fig. 1.

On Fig. 1, *c* is shown the change of the position of this layer inside the deformation zone, and on Fig. 1, *d* is shown the position of this layer at the exit from the deformation zone. Photographs (Fig. 1, *b-d*) prove the possibility of using a mechanical "ball model" for studying the kinematics of the deformation zone.

On Fig. 2 fragments of changes in the positions of the points of the outer initial (darkened $1^{/}$) layer of the stock material before entering the deformation zone (Fig. 2, *a*), in the deformation zone (Fig. 2, *b*) and outside the deformation zone (Fig. 2, *c*). Analysis of the photographs on Fig. 2, *a, b, c* shows that the points of the stock material on the outer surface before entering the deformation zone (the dark balls in Fig. 2 *a*) remain on the outer surface of the stock both in the deformation zone (Fig. 2, *b*) and outside the tool (Fig. 2, *c*). Between them fresh points of the stock material from the inner (deep) layers of the stock (white balls in Fig. 2, *b*) appear inside the deformation zone, which remain on the contact surface of the stock, providing conditions for monotonous deformation of the stock during

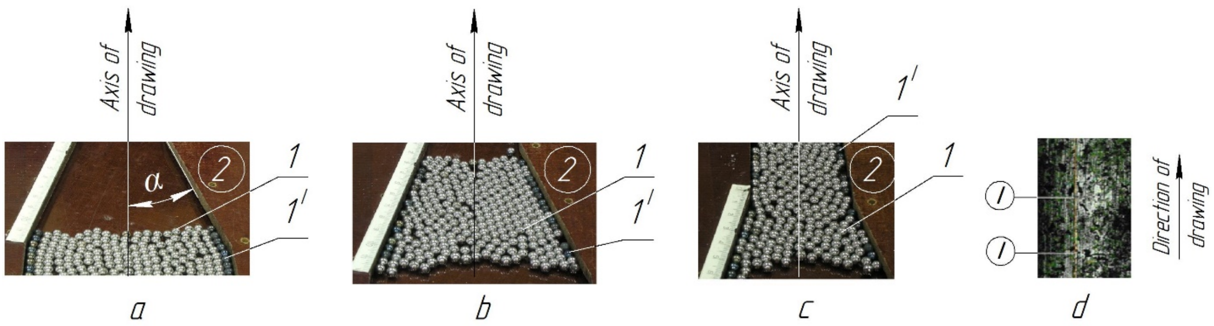

Fig. 2

laminar flow of the stock material [7,8] . This type of relative sliding of the stock material causes uneven wear of the outer surface of the elongated stock. On Fig. 2, *d* is shown a fragment of the outer surface of an elongated wire (x100), on which areas of increased wear alternate [7].

Fig. 3 shows the results of the research of the influence of the drawing conditions (increase of the strength properties of the stock material due to increasing the mutual attraction of magnetized balls) on the formation of breaks and cracks (voids) inside the deformation zone and beyond it according to the scheme (Fig. 3, *a*) of the formation of these voids [5]. On Fig. 3, *a - d, e* are shown photographs of the process of modeling of the cracks forming during drawing. In a continuous stock (Fig. 3, *a*), when it moves within the deformation zone crack appears (Fig. 3, *b*) T_M due to the formation of a "vortex" from a darkened layer of balls. As you move in the deformation zone T_M decreases (heals) up to dimensions

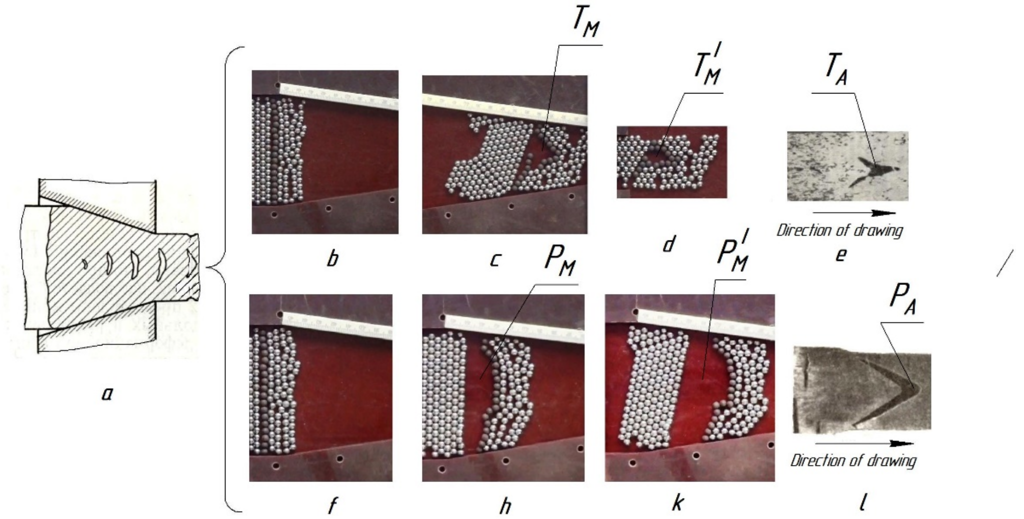

Fig. 3

$T_M^| < T_M$ and stays inside the outstretched stock (Fig. 3, *c*). An example of such a crack in a stretched stock is shown in Fig. 3, *e* [5].

On Fig. 3, *f - k, e* are shown photographs of the modeling of the destruction of the stock material associated with a further increase of the mutual attraction of magnetized balls. In the continuous stock (Fig. 3, *f*), at the beginning of the deformation zone (Fig. 3, *h*) the process of destruction begins (P_M), which during movement of the stock inside the deformation zone (Fig. 3, *k*) increases ($P_M^/ > P_M$) and in the real conditions leads to the destruction of the material of the stock at the exit of the tool (Fig. 3, *l*) [5].

Conclusions

1. Mechanical model of the deformation zone in the form of colored magnetized metal balls moving in a geometrically similar model of monolithic tool provides visualization of local plastic

deformations depending on the technological parameters of the drawing process and allows broadening our understanding about the mechanic of the process of plastic deformation.

2. In any type of WMP during the stable process of deformation of the stock in the stationary deformation zone «fresh layers of the stock material» come out from the inside of the deformation zone to the contact surface of the tool and stock thereby causing uneven wear of the outer surface of the finished product at constant values of the contact pressure, the coefficient of external friction and the relative sliding speed respectively to the instrument.

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