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**PREDICTION OF SURFACE LAYER STRENGTHENING PARAMETERS DURING
STRENGTHENING TREATMENT OF PARTS**

**ПРОГНОЗУВАННЯ ПАРАМЕТРІВ ЗМІЦНЕННЯ ПОВЕРХНЕВОГО ШАРУ ПІД ЧАС
ЗМІЦНЮВАЛЬНОЇ ОБРОБКИ ДЕТАЛЕЙ**

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When designing technological processes of machining and strengthening, the main tasks are the analytical calculation of the expected degree of deformation, the depth of the hardened layer and the surface roughness. When inserting the indenter into the surface of the part in the contact area there is a residual dent (plastic imprint) around which there is always a plastically deformed area that extends to a certain depth h_n .

Analytical determination of the thickness of the reinforced layer and the degree of deformation depending on the physical and mechanical properties of the material of the part and the process parameters is a very difficult task. As a result of theoretical researches the specified dependences for definition of depth of the strengthened layer differing in consideration of influence of the form of a contact spot which is described by coefficient K are received:

$$K = 1 - \frac{1}{2} \left(1 - \frac{b}{a} \right)^4, \quad (1)$$

where a i b – half-axis of the contact ellipse.

Dependence to determine the depth of the reinforced layer h_n in the processing of ball rod hardener (PBRH) obtained taking into account the fact that the formation of qualitative characteristics of the surface layer in this type of processing is influenced by the following factors: the impact energy of the drummer E_y , the number of rods in the nozzle N , diameter of sharpening of an indenter (rod) D_{in} , impact energy loss, taking into account the efficiency η ; physical and mechanical properties of the material of the part:

$$h_n = 1,68 \cdot \sqrt[4]{\frac{E_y \cdot \eta \cdot D_{in}}{N \cdot HB^{1,12} \cdot 10^6}}, \quad (2)$$

where D_{in} – indenter sharpening radius; HB – the hardness of the material of the part according to Brinell в kgf/mm^2 .

Under the degree of deformation ε , conditionally accepted the ratio of the diameter from the indentation of the hole d to the diameter of the pressing sphere D .

$$d = \left(\frac{D \cdot E_y}{0,1 \cdot HD} \right)^{\frac{1}{4}}, \quad (3)$$

where HD – dynamic hardness of the material of the part in Pa.

In practice, quite often resort to converting some hardness numbers to others. These calculations are performed solely on the basis of empirical dependencies, which fully describe the internal relationships between different hardness numbers. The presented dependences for determining the degree of deformation are obtained taking into account the conversion of Brinell hardness (kgf/mm²) to dynamic hardness (MPa):

$$= 0,2 \cdot HD^{0,89},$$

To determine the degree of deformation during machining of parts by dynamic methods of PPD, the following dependences are obtained:

for VPSP:

$$\varepsilon = 0,8 \cdot \sqrt{V_{\text{эф}}} \cdot \sqrt[4]{\frac{\rho_{\text{ш}}}{HB^{1,12} \cdot 10^6}}, \quad (5)$$

for PBRH:

$$\varepsilon = 0,67 \cdot \sqrt[4]{\frac{E_y \cdot \eta}{N \cdot HB^{1,12} \cdot R_{\text{ш}}^3 \cdot 10^6}}, \quad (6)$$

where $R_{\text{ш}}$ – rod sharpening radius.

When designing technological processes of machining and strengthening it is important to determine the required processing time of the part. It is important to avoid such phenomena during processing as pre-riveting, which leads to a decrease in strength, peeling, peeling of the surface layer of the metal and the appearance of cracks in it.

For the most accurate forecasting and planning of the technological process, the dependence for calculating the processing time at a given amount F of the deformation of the entire volume of the surface layer with the thickness required for the formation of the specified parameters of hardening:

$$t_F = \frac{4 \cdot h_{\text{max}} \cdot F \cdot R^2}{V_s \cdot f_{\text{с}}}, \quad (7)$$

where F – the required number of repeated blows to the same point of the treated surface; V_s – the volume of metal enclosed in a spherical segment of radius is deformed R and height h_{max} ; $f_{\text{с}}$ – the frequency of cycles of the mass of the balls on the surface of the part.

The results of experimental studies conducted to verify the obtained theoretical dependences for calculating the depth of the hardened layer, the degree of deformation of the surface of parts during machining by dynamic methods of PPD, determination of empirical coefficients and time of crosslinking of samples of different materials with different processing methods. Figures 1-3 show the dependences of the change in the depth of the reinforced layer on the diameter of the ball, the frequency of rotation of the bottom of the working chamber, the physical and mechanical characteristics of the material of the

workpieces at CRPSP. The theoretical curve is represented by a solid line, and the points are the values obtained as a result of experimental studies with confidence intervals (95%).

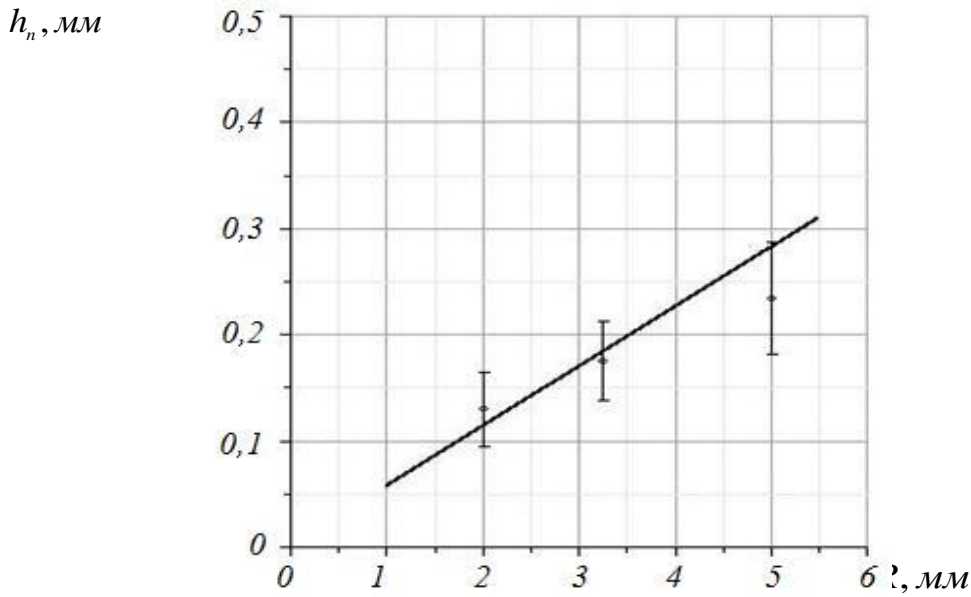


Figure 1. The dependence of the change in the depth of the reinforced layer on the radius of the ball $\omega = 10$ Hz, $\sigma_T = 240$ MPa for D16.

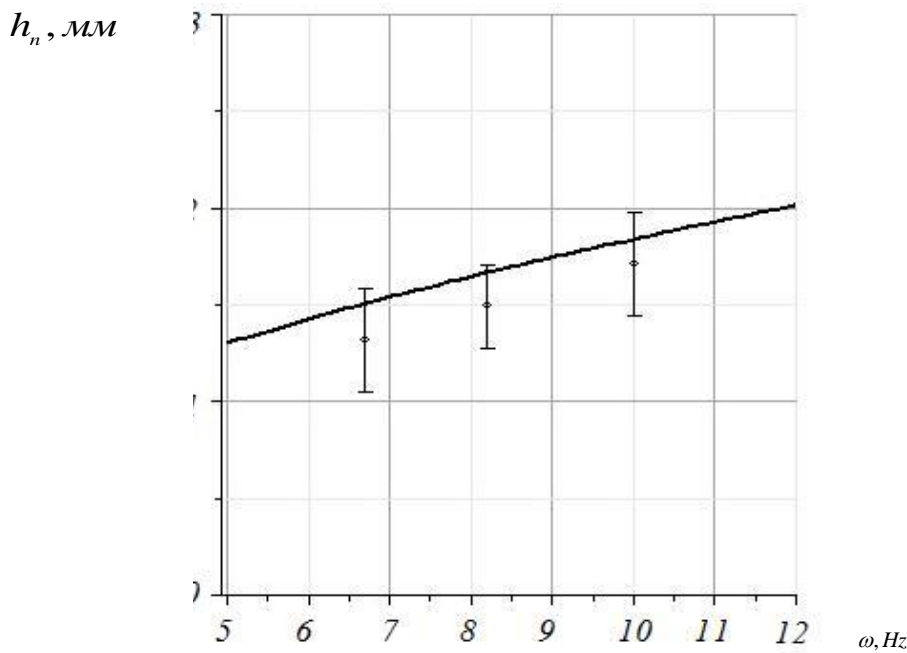


Figure 2. Dependence of change of depth of the strengthened layer on frequency of rotation of a bottom of a working chamber at $R = 3,25$ mm, $\sigma_T = 240$ MPa for D16.

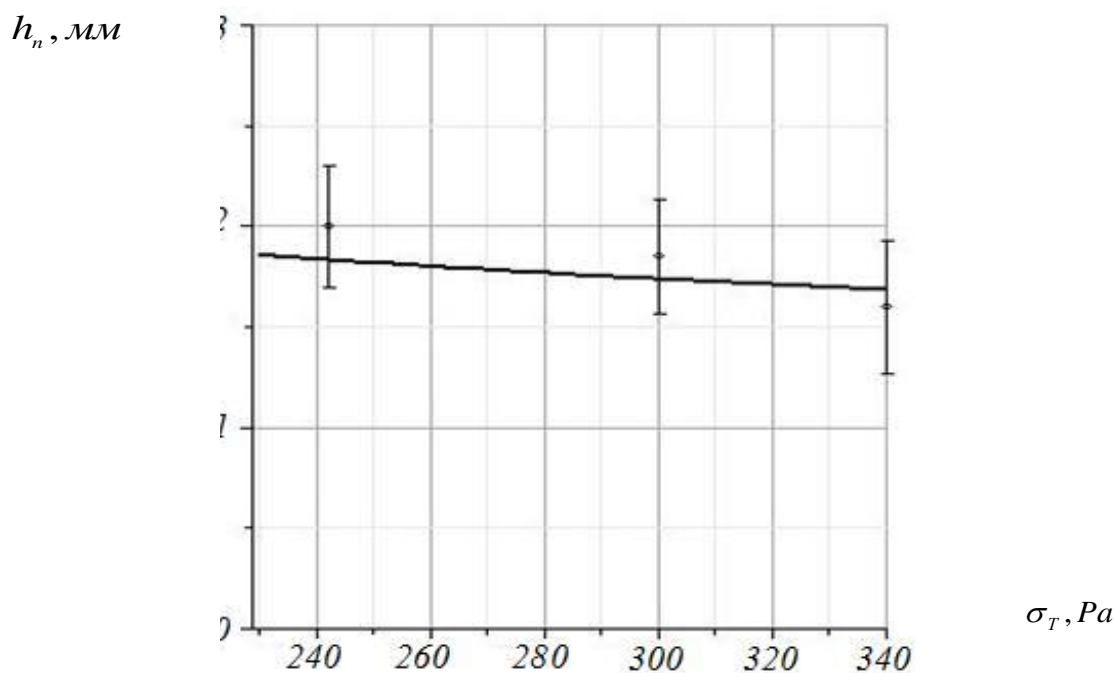


Figure 3. The dependence of the change in the depth of the reinforced layer on the yield strength of the material at $R = 3,25$ мм; $\omega = 10$ Hz.

The paper considers the problem of analytical prediction of surface layer strengthening parameters during machining by dynamic methods of surface plastic deformation. Based on the consideration of the physical and mechanical properties of the material, process parameters, and contact zone geometry, theoretical dependences were obtained for determining the depth of the hardened layer and the degree of deformation during vibration processing, centrifugal-rotary processing, and processing with a ball-rod hardener.

The derived analytical dependences take into account the Hencky–Mises plasticity condition, the shape of the contact spot, speed parameters of the process, geometric characteristics of the indenter, and the hardness of the workpiece material. Relationships for determining the degree of deformation were proposed taking into account the conversion between different hardness scales, which makes them suitable for practical engineering calculations. An expression for determining the required processing time was also obtained, ensuring the formation of a hardened layer of a given thickness without undesirable phenomena such as over-peening, delamination, surface layer peeling, and crack formation.

Experimental studies carried out on centrifugal-rotary and vibration processing machines, as well as using a ball-rod hardener, confirmed the adequacy of the obtained theoretical dependences. A satisfactory agreement between experimental data and calculated values of the hardened layer depth was established with a confidence probability of 95%. The influence of ball diameter, rotation frequency of the working chamber bottom, and physical and mechanical properties of the workpiece material on the intensity of surface layer strengthening was demonstrated.

The obtained results can be used in designing technological processes of strengthening treatment of machine parts by dynamic SPD methods for the justified selection of processing modes, prediction of surface layer parameters, and improvement of operational characteristics of products.

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**RESEARCH ON THE INFLUENCE OF DESIGN PARAMETERS
ON THE STRESS-DEFORMED STATE OF WORKING BODIES OF THE CUCUMBER
AND MELON SEEDS SEPARATOR**

**ДОСЛІДЖЕННЯ ВПЛИВУ КОНСТРУКТИВНИХ ПАРАМЕТРІВ
НА НАПРУЖЕНО-ДЕФОРМОВАНИЙ СТАН РОБОЧИХ ОРГАНІВ СЕПАРАТОРА
НАСІННЯ ОГІРКА ТА ДИНИ**

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Mechanization of primary processing processes of melon and vegetable crops is one of the priority areas of development of agricultural engineering. The production of cucumber and melon seeds deserves special attention, the demand for which is steadily growing both in the domestic and foreign markets. The efficiency of seed separation is largely determined by the quality of the separation equipment. The issues of mechanization of seed separation processes from melon and vegetable fruits are considered quite widely in the works of domestic and foreign scientists, however, comprehensive studies of the stress-strain state of separation equipment remain insufficiently covered.

The general principles of design and calculation of vibrating separators are outlined, where approaches to the selection of structural and kinematic parameters of screens are systematized. It is shown that under variable operating modes, the amplitudes of dynamic forces can exceed static ones by 1.8–2.4 times, which is fundamentally important for assessing the resource of parts. At the same time, the specifics of the interaction of the mechanism with elastic-viscous raw materials (fruit pulp) are not taken into account in this work [1].

A comparative analysis of the designs of melon processing machines was conducted and it was found that the hinged suspensions of the screens are most susceptible to fatigue failure of the nodes due to the alternating nature of the loads. It was found that the stress concentration in the areas of the connections of the connecting rod with the crank and the connecting rod with the slider are critical from the point of view of fatigue strength, and it is recommended to use smooth fillets with a radius of at least 3 mm [2]. It was found that the viscosity of the mixture varies in the range of 0.8–3.2 Pa·s depending on the degree of ripeness of