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MODELING OF THE RESIDUAL STRESSES ON THE TREATED SURFACE MACHINE PARTS

Розглянуто особливості утворення залишкових напружень у поверхневих шарах оброблених деталей. Запропонована нова методика розрахунку глибини різання на чистових операціях для зняття шару пластичної деформації після чорнового оброблення, яка забезпечує мінімальні залишкові напруження у поверхневих шарах деталей машин.

In the article the features of the formation of residual stresses in the surface layers of machined parts are outlined. A new method of calculating the depth of cut for finishing operations to remove a layer of plastic deformation after the rough handling that provides minimal residual stresses in the surface layers of machine parts is discribed.

Statement of the problem. One of the main tasks of engineering is developing effective technological processes of manufacturing details, which provide not only high accuracy and surface quality at the lowest cost, but also the preservation of these properties throughout the life of the product. Experience operating machinery convincing evidence are that their reliability is defined as the surface layer of details and depends on the nature of the contact. According to the results of many studies, including D. Papsheva, I. Kudryavtseva, J. Schneider, U. Baabe, P. Yascheritsyna, P. Linchevskiy, V. Starkov and others it is found that performance significantly determine the quality of the surface wear resistance, toughness, corrosion resistance and other performance properties of machine parts. One of the factors that lead to lower quality of surfaces of machine parts during operation are residual stresses arising from mechanical processing. Creation of the surface layer and the formation of residual stresses, resulting in decreased reliability and reduced service life of machine parts and their performance properties.

Analysis of recent research. The most important characteristics of quality parts in terms of technological production thereof are accurate and the state of the surface layer of details. Residual stress is an important factor influencing the quality of surface fatigue strength and wear parts. According to research I. Sokolova and V. Ural [5] stresses of the first kind, which arise as a result of treatment, with the greatest impact on the quality of the surface, technology and performance. The emergence of the first kind of residual stresses due to inhomogeneous plastic deformation of the metal during its machining and uneven heating of the surface layers. Residual stresses of the first kind in the superficial layers of size and sign depend on the following factors: the cutting forces that determine the degree of plastic deformation, heat in the cutting zone, physical and mechanical properties of the material. Analysis of the causes and nature of the destruction of machine parts suggest [1, 2], mainly destruction begins in the surface layer and the resistance to fracture is defined as a set of characteristics of the surface layer of details of machines: micro geometry (surface roughness, shape and arrangement of microscopic, etc.), strengthening and residual stresses. The works of A. Isabel [3] A. Catalina [4] A. Sulima [6] investigated the formation of a hard metal surface layer and shows the classification of residual stresses. Shown that cutting the cutting tool on the work piece surface is influenced not only the effort, but the temperature in the cutting zone. The influence of cutting conditions on the distribution of residual stresses and conditions that ensure the appearance of the surface layer of compressive stresses that guarantee improved physical and mechanical properties of the surface layer and increase the wear parts. The stability of the working surface detail is achieved by reducing the initial process of residual stresses. Almost all engineering processes give rise to residual stresses. In most cases, residual stresses play a negative role. Under the influence of external loads during subsequent machining or operation of residual stresses can exceed the elastic limit, resulting in non-uniform plastic deformation, warping, etc. Besides destruction may occur. Residual stresses reduce the strength of products of the variables and cyclic loading affect the wear of the friction of sliding or rolling. The works of A. Sulima [6] P. Yascherytsyna [7] showed that residual stresses technologically driven. This means that the magnitude and sign, and the distribution of residual stresses in the depth of the surface layer depend on the types and modes of processing work pieces. By changing the parameters and methods of processing a sequence of blanks, you could end up getting favorable magnitude and distribution of residual stresses in the surface layer.

Formulation the purpose of article. The aim is to reduce the residual stresses in the surface layers of the treated surfaces in the direction of the velocity vector cutting on finishing (final) operations.

The main material. Significant residual stresses may appear after machining (turning, grinding, etc.). The appearance of residual stresses due to plastic deformation under the influence of the cutting tool and the heating of the surface layers in the cutting zone. If there is an instrument of coercion plastic deformation, leading to the formation of residual stresses it remains after machining. In the manufacture of parts of the surface layer acquires new properties that are different from those of the starting material. The set of properties of the work piece material and the layer underneath characterize the quality of the surface layer of the work piece or the quality of treatment. When cutting parts sharpening is a complicated interaction on the work surface details as cutting forces and temperatures in the cutting zone. As a result of this interaction in the surface layer of details there are very complex processes of structural and phase changes of elastic-plastic deformation. Then processing is sharpening surface plastic deformation of metals and formed its crystal lattice. Under the influence of deforming force is formation of change single layer of atoms relative to another. At the elementary areas where distortions of the crystal lattice under the limit, with a further additional distortion in the same direction caused Finishing operations may be cracks. Therefore, the integrity of the machined surface depends on the nature and direction of existing and newly formed crystalline landslides. In the same direction shifts mikro destructions surface layer increase, and in opposing directions existing mikro cracks are closed. Residual stresses depend on the presence of dislocations in the material. Value as the distribution of residual stresses due to type and sign of excess dislocations and their distribution by volume of deformed material. Therefore, we can state the relationship between the residual stresses and the density of dislocations with other characteristics of the fine structure of the surface layer of metals after processing machining. Hence follows an important practical conclusion – to try to develop processes so that the processed sequentially implemented operations were carried out in more than one direction of the cutting elements on the work piece, and the opposite. Therefore, the proposed method of residual stress change of direction of the velocity vector cutting on finishing (final) operations, a way to reinstall the work piece and the method of calculating the depth of cut at t1 finishing operations to remove a layer of plastic deformation after the rough treatment (Fig. 1), which provides the minimum residual stress in the treated surface layers of machine parts.

The depth of the layer distribution of plastic deformation after rough handling is determined by the relationship:

$$h_s = \sqrt{\frac{P_y}{2\sigma_T}}, \tag{1}$$

where σ_T – liquid limit of the material, MPa; P_y – radial cutting force, N.

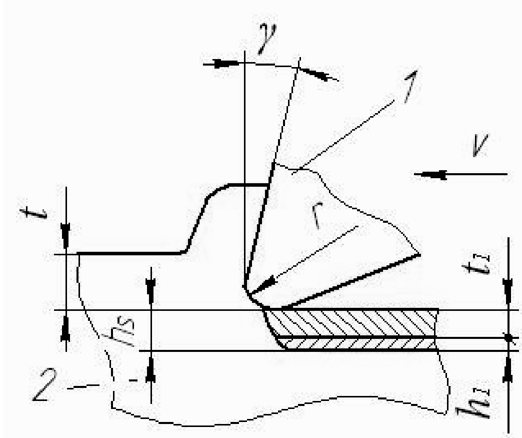

Figure 1. Cutting Scheme
1 – cutting blade, 2 – work piece; v – speed cutting; t – depth of cut for rough cutting;
h_s – the depth of plastic deformation during rough cutting; t_1 – cutting depth fine-finish processing;
h_1 – depth distribution of plastic deformation of fine-finish processing.

The magnitude of cutting forces during rough cutting is determined by the relationship:

$$P_y = 10 \cdot C_p \cdot t^x \cdot s^y \cdot v^n \cdot K_p = C_1 \cdot t^x \cdot s^y \cdot v^n , \quad (2)$$

where *t, s, v* – by depth, feed and cutting speed; x, y, z – exponent; $C_1 = 10 \cdot C_p \cdot K_p$ – coefficient which takes into account the influence of the material and the cutting tool.

Depth h_s characterizes the thickness of the distortion of the machined surface due to plastic deformation and distortion of the crystal lattice of the metal. To correct the distorted surface it is necessary that the thickness of the layer at which plastic deformation was distributed at h_s when the direction of the velocity vector cutting on clean processing operations.

For minimal residual stresses need to performed the following condition (Fig. 1):

$$\frac{h_s}{t_1 + h_1} = 1 , \quad (3)$$

where t_1 – cutting depth fine-finish cutting, mm; h_1 – depth distribution of plastic deformation of fine-finish cutting, mm.

Depth of cut while finishing cutting conditions determined by the minimum value of plastic deformation of the surface of the parts:

$$h_s - t_1 = \sqrt{\frac{C_1 \cdot t_1^x \cdot s_1^y \cdot v_1^n}{2\sigma_T}} , \quad (4)$$

To investigate the residual stresses produced designs – rings annealed steel 45 GOST 1050-88. Treatment samples were screw-cutting lathe 1A616 when cutting conditions: rough turning – t = 1 mm, s = 0,26 mm / rev, n = 560 min^{-1}; finish turning – t_1 = 0,35 mm, s_1 = 0,08 mm / rev, n_1 = 1120 min^{-1}.

After cutting the ends of the rings perpendicular to the generatrix plot the two slashes at a distance of 4 mm and cut the ring on generators between dashes. In instrumental microscope measured the distance between dashes to determine the deformation ring.

To determine the residual tangential stresses applied method Andersen-Falmana [5]:

$$\sigma_t = \frac{E \cdot s \cdot \Delta D}{\left(1 - \mu^2\right) D_{ñð}^2} , \quad (5)$$

where ΔD – changing the diameter of the ring is cut, mm D_{sr} – diameter of the middle circle ring, mm, E – Young's modulus, MPa; μ – Poisson's ratio; s – wall thickness, mm.

The results are presented in Table 1:

Table 1

The results of experimental studies

№ sample	Diamete *D*, mm	The inner diameter, d, mm	Wall thickness, s, mm	Changing the outside diameter, ΔD, mm	The residual tangential stress σ_t, MPa	Comment
1.	49,95	38,3	4,47	0,076	44	working in one direction
2.	49,95	38,3	4,47	0,022	12	
3.	49,95	38,3	4,47	0,045	25	
4.	49,94	38,5	4,37	0,007	4	working in the opposite direction
5.	49,94	38,5	4,37	0,005	3	
6.	49,94	38,5	4,37	0,003	2	

Conclusions. Reserve for increasing competitiveness and improving the performance of products is technological quality parameters of surface layers of the executive (working) surface details.

Knowing the amount of plastic deformation and residual stress in the work piece, can provide ways to eliminate residual stresses by changing the direction of the velocity vector while finishing processing.

It was established experimentally that in roughing and finishing processing in one direction residual stresses of the first kind are 12 ... 44 MPa, while roughing and finishing in reverse transformation stresses are minimum values (2 ... 4 MPa).

Our studies confirm the promise of using this method for solving technological problems related to the improvement of quality and reduction of residual stresses in the surface layers of the treated surfaces.

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