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Influence of The Design of The Rolling Roller on The Quality of The Surface Layer During Plastic Deformation on the Workpiece

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Abstract: The method of surface plastic deformation of the outer diametrical surfaces of machine parts, where the deformation is transferred by the tool element, which is a rolling tool with two working profile radii, and the tool is additionally imparted with a rotational motion about the OX axis passing through the plane connecting the two rollers and perpendicular to the axis OY blanks. The effect of deformation kinematics on the quality characteristics of the hardened layer of manufactured parts is considered: roughness, residual stresses, work-hardening depth, hardness HRC, HB and microhardness. The analysis of the efficiency of parts hardening when machining with a roller with two radii, in comparison with deformation by a roller with one radius.

Keywords: two radius roller, deformation hardening, surface plastic deformation, surface layer quality, roughness, hardness.

INTRODUCTION

To improve the reliability, increase the durability of parts in industry, surface plastic deformation technologies are widely used. Rolling hardening methods for processing surface plastic deformation are easy to manufacture, economical, productive, provide low roughness, a given depth and degree of hardening, residual compressive stresses in the surface layers, structure and other indicators of the quality of the surface layer of processed parts.

Surface plastic deformation is carried out by a local deforming tool (ball, roller, disk, tapered and cylindrical rollers, etc.). Plastic action allows for finishing and hardening processing of cylindrical parts of complex and simple shapes.

The technology developed for the processing of surface plastic deformation of rigid shafts (large diameter and short length) cannot be used for processing low-stiff shafts without significantly increasing the rigidity of the technological system, creating special tools and equipment. With plastic deformation of parts of low rigidity (thin-walled, parts), the possibilities of hardening methods are limited. Due to the low bending stiffness of the workpiece, vibrations in the mechanical system, the difficulty of achieving a given product quality, the quality and productivity of processing, as well as the lack of the necessary technological equipment. Plastic deformation of even only the surface layer causes significant deformation and movement of metal particles, which adversely affects the design of the product.

The purpose of this work is to study the quality of the surface layer roughness when using a new technological scheme of surface plastic deformation and compare the experimental results with the data obtained when processing parts with a conventional cylindrical roller with one radius.

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Physical properties of deformation processing. The main hardening mechanisms that provide an increase in the plastic flow stress can be classified on the basis of the geometric dimensions of the “obstacles” that hinder the movement of dislocations (substructure elements, grain boundaries, dissolved atoms, dislocations by dispersed particles). The most effective hardening of materials can be realized through targeted technological effects on the structure of metals to increase the density of dislocations and create a dislocation substructure to increase the shear resistance of the hardened material.

Thus, the ways to increase the strength of materials consist in the development of strengthening technologies that ensure the formation of such a structural state of the material in which the basic principles of the dislocation theory of hardening are maximally implemented. The stress state loading can be achieved if the deformation distortion of the material grains is enhanced. Hence, a technological problem arises: it is necessary to create such a design and kinematics of a working local tool that would enhance the distortion of the material structure during surface plastic deformation while maintaining the quality of the part and its surface layer.

Reverse tool design. In the processing of surface plastic deformation, it is known and widely used local and hardening methods of rolling parts with a cylindrical, tapered roller. The process of local plastic deformation is represented by a cylindrical roller rotating about the horizontal axis OX. Moving in the axial direction along the surface of a rotating cylindrical sample, the rolling roller creates a helical path of the plastic trace on the surface to be treated. From the point of view of deformation distortion of the microstructure, this process is ineffective.

The method for intensifying the stress state in the deformation zone consists in changing the design of the working tool, which should enhance the distortion of the fine-grained surface of the material. In the proposed method of surface plastic deformation of the outer cylindrical surfaces of machine parts, the deforming element of the tool is a rolling tool with two profile radii. In this case, the tool is additionally imparted with a rotational movement about an axis passing through the plane connecting the two rollers and perpendicular to the workpiece axis.

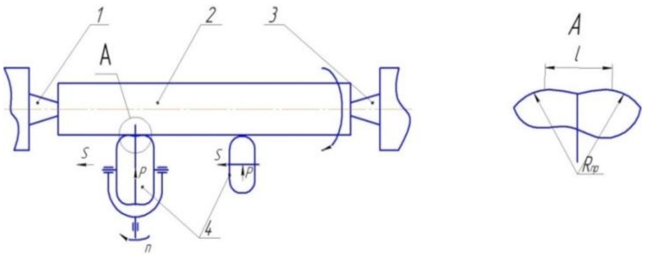

Fig. 1. Schemes of hardening treatment with two radial (I) and one radial roller (II) on a lathe (a) and a view of the working part with two radial rollers (b):

1 - rotating centers; 2 - blank; 3 - tailstock; 4 – tool

When the rolling roller rotates around the diametral axis, plastic fields of different directions are superimposed, which should contribute to the distortion, "mixing" of the structure in the surface layer and increase the efficiency of hardening treatment. In fig. 1 shows a diagram of the implementation of this method of surface plastic deformation.

Experimental research technique. The studies were carried out on cylindrical specimens with a diameter of 20 mm, made of steel 45 on a 16K20 lathe. For hardening, a single radius cylindrical roller made of U12 steel, 30 mm in diameter with a profile radius of P_{pr} = 5 mm, was used. I-40A oil was used as a technological lubricant. Processing modes: feed s = 0.21 mm/rev, roller penetration depth (interference) 0.1 mm, workpiece rotation frequency n = 125 min^{-1}.

Rolling with a roller is performed on a turning machining center with a penetration depth also equal to 0.1 mm. Processing modes: feed s =0.21 mm/rev, workpiece rotation frequency n_3 = 125 min^{-1} and tool n_i = 1200 min^{-1}. Lubrication - I-40A oil.a two-radius roller is made of U10A steel with a profile radius P_{pr} = 3 mm, distance l = 2 mm (see Fig. 1, b).

The double radius roller can also be used to harden parts on conventional lathes. This will require a fairly simple device, consisting of a three-phase electric motor with a power of 1 ... 1.5 kW with an adjustable speed. On the shaft of the electric motor, a rotating center is fixed to which the tool is. The device is installed instead of the tool holder on the lathe slide.

The measurement of the roughness parameters on a profilometer after hardening of surface plastic deformation was carried out using a profilograph - a PCh-2 profilometer using inductive and laser interferometric sensors. The device is capable of measuring shape deviations within a limited surface, waviness, directions of irregularities, surface flaws, as well as roughness parameters, including those corresponding.

Using a hardness tester HB ТС-СР-Ц-187,5, the Rockwell surface hardness was obtained for a steel ball with a diameter of 1.588 mm (HB). Rockwell hardness is determined from the indentation depth of the tip. The indentation was carried out under the action of two sequentially applied loads - preliminary and final (total), equal to 100 and 980 H, respectively. The hardness was found from the difference in the indentation depths of the indentations. The depth of the indentation under the action of the main load was recorded by an indicator, and the hardness according to HB after measurement was counted on the screen of the hardness tester.

To determine the microhardness, a ПМТ-3microhardness tester was used with a loading force of 200 g. During testing, the diagonal of the indentation ∂ was measured and the microhardness$\boldsymbol{H}_{ц}$ (Н/мм^2) was obtained from the corresponding tables (for a given load P).

An AS-Tester device was used to measure the residual stresses. Measurement mode: chromium anode, K-α radiation, X-ray tube voltage - 25 kV, current - 5.5 mA. Both detectors were used, the collimator was 5 mm. Diffraction angle - 156.4 °. Reflection plane.Number of inclinations - 8, incline deviation (oscillation) ± 5 °.

Exposure time - 5 s. The stresses were measured in two directions (φ): 0 ° (position of the goniometer along the sample) and 90 ° (position of the goniometer across the sample). Normal stresses were determined using one of the standard methods for calculating Peakfit peaks, offered by the instrument software. For the automated calculation of stresses, material parameters were introduced: Young's modulus - 210 GPa; Poisson's ratio - 0.3.

The study of the metal microstructure was carried out on a MET-2 metallographic microscope designed for visual observation of the microstructure of metals, alloys and other opaque objects in reflected light under direct illumination in a bright field, as well as for studying objects in polarized light. The samples were prepared and poured into molds on a press, followed by grinding with emery paper of various grain sizes, etching with alcohol and 5% nitric acid. The program was used to photograph the structure of the metal.

Conclusions of the experiment. Further, the influence of the considered hardening schemes on the main characteristics of the quality of the surface layer is shown: roughness, surface hardness, residual stresses, microstructure and work-hardening depth.

Roughness. The roughness profile diagram for rolling with two and one radius rollers is shown in Fig. 2, where it can be seen that the height and degree of filling of the microroughness cavities have better results when machining with two radius rollers. Before hardening, the samples had the following initial values of the roughness parameters: Raisx = 1.7 microns, Psisx = 13 microns. After running in with one radius roller, Pz and Pa decrease by 2 and 2.2 times, respectively, and when machining with two radius rollers - by 2.9 and 3.5 times.

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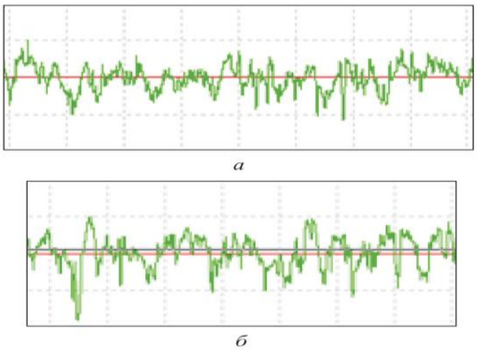

Fig. 2. Diagram of the roughness profilogram during rolling with two radius (a) and one radius (b) rollers

In fig. 3 shows the effect of processing modes on the roughness parameter Pa. At low values of the tightness, the distortion of the micro - profile is small, the microroughnesses are not completely deformed. Fig. 3, a shows that with an increase in the interference, the surface roughness decreases to a certain value. A further increase in the tightness (t> 0.2 mm) leads to an increase in roughness, which is the result of an increase in plastic distortions and the formation of microcracks, which cause destruction of the surface layers due to over-hardening.

The influence of feed on the roughness parameter Pa is shown in Fig. 3, c. At low feed rates, the degree of overlap of the deformation centers is greatest, which makes it possible to achieve a minimum height of microroughnesses. With an increase in feed, the deformation decreases - the roughness increases, which contributes to the formation of a completely new surface profile. When machining with one radius roller, the roughness parameter Pa decreases by 3.1 times, and when running in with two radius tools - by 11 times.

The roughness of the surface decreases with an increase in the frequency of rotation of the tool (Fig. 3, b). After hardening, the parameters of roughness Rz and Ra decreased by 4 - 4.3 - times in comparison with the initial roughness of the workpiece. With an increase in the rotation speed of the workpiece, the surface roughness increases slightly (Fig. 3d). This is due to the fact that at low rolling speeds, a more complete crushing of irregularities occurs. Plastic deformation prevails over elastic deformation due to the fact that the impact of the roller per unit area at low rolling speeds is longer. With an increase in speed, the time of action of the roller on the surface layer decreases, and elastic deformation prevails over plastic deformation. The increase in plastic deformation lags behind the increase in the rate of load application. However, an increase in the processing speed has an insignificant effect on the surface roughness.

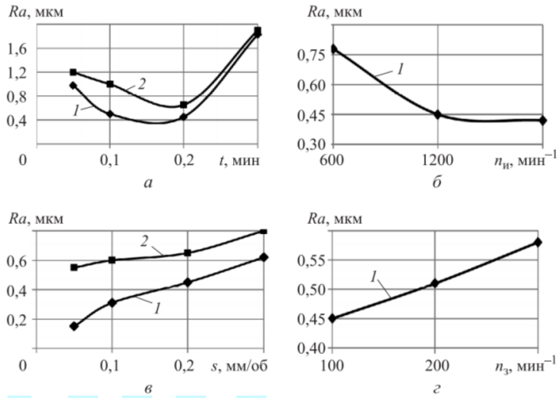

Fig. 3. Dependences of the processing modes with two radius (1) and one radius (2) rollers on the roughness parameter Ra at the initial roughness of the workpieceRa$_{isx}$ = 1.69 (left) and 1.7 mkm (right): a-tightness t (1-n$_3$=125min^{-1}, n$_i$=1200 min^{-1}, s =0.21 mm/rev; 2-n$_3$=125 min^{-1}, s =0.21 mm/rev); b - tool rotation frequency (n$_3$=125 min^{-1}, t=0.2 mm, s=0.21 mm/rev); c- feeds with (1- n$_3$=125 min^{-1}, n$_i$=1200 min^{-1}, t=0.2mm; 2- n$_3$=125 min^{-1}, t=0.2 mm); r- workpiece rotation frequency n$_3$ (t=0.2 mm, s=0.21 mm/rev, n=1200 min^{-1})

Surface hardness. When running in with two radius rollers, the surface layer is deformed many times and to a greater extent than when running in with one radius roller. As a result, the hardness increases by 9.4 and 3.5%, respectively, compared to the original hardness (HRB$_{isx}$=85).

The hardness of parts when machining with two radius rollers can be increased by 21%, when running in one radius roller - by 12% compared to the original hardness (HRB_{isx}=85). A decrease in surface hardness with an increase in feed can be explained by a decrease in the frequency of application of a load to the treated area of the sample.

Residual stresses. The results of measuring the residual stresses by the X-ray method are shown from which it can be seen that the axial residual stresses δ_z^{ost} about st is greater than the tangential residual stresses δ_φ^{ost} about st. When rolling with two and one radius and rollers, residual compressive stresses are formed in the surface layers. In this case, the ratio of axial and tangential stresses is 1.7 ... 2, which is consistent with the data of works. When running in with two radius rolls, the surface residual stresses are 1.2-1.5 times higher than when machining with one radius roll.

In fig. 4 shows the effect of processing modes with two and one radius and rollers on the surface residual compressive stresses.

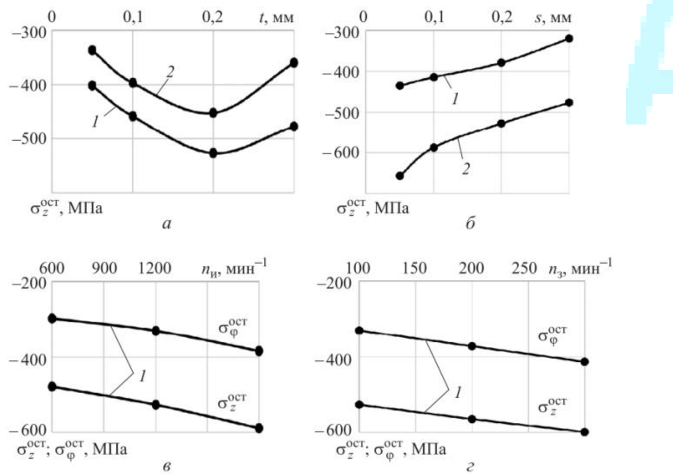

Fig. 4. Dependences of the processing modes with two radial (1) and one radial rollers (2) on the surface residual compressive stresses: a - interference t (1-n_3=125 min^{-1}, n_i=1200 min^{-1}, s=0.21 mm/rev; 2-n_3=125 min^{-1}, s=0.21 mm/rev); b - feeds with (1-n_3=125 min^{-1}, n_i=1200 min^{-1}, t =0.2 mm; 2-n_3=125 min^{-1}, t=0.2 mm); c - tool rotation frequency (n_3=125 min^{-1}, t=0.2 mm, s=0.21 mm/rev); r - the frequency of rotation of the workpiecen_3 (n_i=1200 min^{-1}, t=0.2 mm, s=0.21 mm/rev)

An increase in feed as a result of a decrease in the number of repeated deformations leads to a decrease in residual stresses. An increase in the rolling speed leads to an increase in the resistance of metals to deformation, which is explained by a sharp increase in the speed of dislocation movement, which, in turn, causes an increase in the resistance of the crystal lattice to this movement.

Microstructure. Photographs of the microstructure at the edge of the hardened zone after treatment are presented in the table, where black grains are pearlite and white grains are ferrite.

The considered methods of hardening affect the change in the microstructure in the surface layer. After surface plastic deformation treatment, the grains stretch in the longitudinal section more intensively than in the transverse direction. In this case, grain refinement, destruction of their boundaries and the formation of texture are observed. The initial structure with grains of medium size was 22 µm. When running in with a two radius roller, the grain sizes decrease in the longitudinal and transverse directions by 78.5 and 64.6%, respectively, and when machining with one radius roller - by 65.7 and 46%.

Microhardness and work hardening depth. The local hardening process with two radial rollers, in comparison with rolling with a single radial roller, allows one to obtain a larger gradient of change and the value of microhardness, but a slightly smaller depth of the plastic zone.

According to the results of experimental studies, it was revealed that the quality of the surface layer significantly depends on the kinematics of surface plastic deformation. The choice of the method of surface plastic deformation and the appointment of processing modes must be carried out depending on the technical requirements for the surface layers of the parts.

CONCLUSIONS

1. As a result of experimental studies, it was found that the surface plastic deformation of two radius rollers in comparison with one radius roller has a number of advantages in relation to the quality of the hardened layer. So, the surface roughness decreases by 3 - 3.5 times, the hardness of the surface layer increases by 6 ... 8%, the residual compressive stresses in the surface layer increase by 1.2-1.5 times. It should be noted that when hardening with two radial rollers, the depth of the work-hardened layer is somewhat lower.

2. The most significant influence on the microgeometry of the surface during rolling with two radial rollers is exerted by the interference fit and longitudinal feed of the tool, less significant - by the rotational speed of the tool and part. In this case, the roughness parameters are reduced by 11 times, and the surface hardness of the parts increases by 21% compared to that for the original workpiece. When machining with a conventional one radius roller, the roughness parameter Pa decreases by 3.1 times, and the surface hardness of the parts increases by 12%.

3. The results of experimental studies make it possible to choose a hardening method to obtain the specified characteristics, the quality of the surface layer of machine parts. The results obtained provide a basis for the development of combined methods of surface plastic deformation, providing a high quality of the surface layer for a number of indicators.

LITERATURE

1. Nomanjonov, S., et al. "STAMPDESIGN." *Экономика и социум* 12 (2019): 101-104.
2. Тешабоев, Анвар Эргашевич, etal. "МАШИНАСОЗЛИКДА ЮЗА ТОЗАЛИГИНИ НАЗОРАТИНИ АВТОМАТЛАШ." *Scientificprogress* 1.5 (2021).
3. Рубидинов, ШохрухҒайратжонЎғли. "БИКРЛИГИ ПАСТ ВАЛЛАРГА СОВУҚ ИШЛОВ БЕРИШ УСУЛИ." *Scientificprogress* 1.6 (2021): 413-417.
4. Nomanjonov, S. N. "Increase The Wear Resistance And Service Life Of Dyes Based On Modern Technologies." *The American Journal of Engineering and Technology* 2.12 (2020): 67-70.
5. Файзиматов, ШухратНумонович, ШухратМахмуджоновичАбдуллаев, and АхаджонАкрамжонўғлиЎлмасов. "КИЧИКДИАМЕТРГАЭГАБЎЛГАНЧУҚУРТЕШИКЛАРНИДОРНАЛАРЁРДАМИДАИШЛОВБЕРИШДАЮЗААНИҚЛИГИНИОШИРИШ." *ScienceandEducation* 2.3 (2021): 181-187.
6. O'LmasovAhadjonAkramjon, O'G. "NEW APPROACHES IN THE DIAGNOSIS AND MONITORING OF ROTOR OSCILLATIONS USING SHAFT SENSORS." *Science and Education* 1.1 (2020).
7. Отақулов, ОйбекХамдамович, and РасулКаримовичТаджибоев. "КОМПРЕССОРВАЛЛАРИДАГИСАЛБИЙТИТРАШЛАРНИБАРТАРАФЭТИШДАКИМЁВИЙТЕРМИКИШЛОВБЕРИБЦЕМЕНТИТЛАШЖАРАЁНИНИНГМЕТОДОЛОГИЯСИВААФЗАЛЛИКЛАРИ." *МОЛОДОЙ ИССЛЕДОВАТЕЛЬ: ВЫЗОВЫ И ПЕРСПЕКТИВЫ*. 2020.
8. Fayzimatov, Sh N., Y. Y. Xusanov, and D. A. Valixonov. "Optimization Conditions Of Drilling Polymeric Composite Materials." *TheAmericanJournalofEngineering andTechnology* 3.02 (2021): 22-30.
9. Fayzimatov, B. N., and Yu YuXusanov. "PROBLEMS OF GLASS SURFACE QUALITY FORMATION FOR MECHANICAL PROCESSING." *Scientific-technicaljournal* 22.2 (2018): 35-39.
10. Файзимтов, ШухратНуманович, andМухаммадазимАкбаралиевич Рустамов. "ПРИМЕНЕНИЕ ПРОГРЕССИВНЫХ МЕТОДОВ ДЛЯ ОРИЕНТАЦИИ И УСТАНОВКИ ЗАКЛЕПОК В ОТВЕРСТИЕ С ГОРИЗОНТАЛЬНОЙ

ОСЬЮ." *НАУЧНЫЙ ПОИСК В СОВРЕМЕННОМ МИРЕ*. 2017.

11. Файзиматов, Ш. Н., and М. А. Рустамов. "АЭРОДИНАМИЧЕСКИЙ ЭФФЕКТ ДЛЯ АВТОМАТИЗАЦИИ ПРОЦЕССА ПЕРЕКАЧКИ ХИМИЧЕСКИХ АГРЕССИВНЫХ РЕАГЕНТОВ." *Современные исследования* 6 (2018): 112-115.
12. Тураев, ТиркашТураевич, ЯкубАнвархаджаевичБатиров, and БобурбекАбдулҳакимЎғлиТожиев. "Модернизация процесса волочения проволочного изделия." *Universum: технические науки* 3 (60) (2019).
13. Тураев, ТиркашТураевич, ЯкубАнварходжаевичБатиров, andБахромМиродиловичМадаминов. "Сравнительной оценки технического уровня станков и станочных систем." *Збірникнауковихпраць ΛΌГОΣ* (2021).
14. Turaevich, TuraevTirkash, and MadaminovBakhromMirodilovich. "Physical Foundations Structural-Formation, Surface Layer Of Parts." *TheAmericanJournalofEngineeringand Technology* 2.09 (2020): 71-76.
15. Teshabaev, Anvar, and RakhimovSharifjon. "The innovation activity on large uzbekcompanyas a key factor of personnel development." *ACADEMICIA: AnInternationalMultidisciplinaryResearchJournal* 10.5 (2020): 416-423.
16. Turakhodjaev, Nodir, et al. "EFFECT OF METAL CRYSTALLATION PERIOD ON PRODUCT QUALITY." *Theoretical&AppliedScience* 11 (2020): 23-31.
17. Nodir, Turakhodjaev, et al. "Development Of Technology To Increase Resistance Of High Chromium Cast Iron." *The American Journal of Engineering and Technology* 3.03 (2021): 85-92.
18. SHIRINKHON, TURAKHUDJAEVA, TURAKHUJAEVA AZIZAKHON, and SAIDMAKHAMADOV NOSIR. "Methods For Reducing Metal Oxidation When Melting Aluminum Alloys." *International Journal of Innovations in Engineering Research and Technology* 7.10 (2020): 77-82.