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MODELING TECHNOLOGICAL SUPPORT THE PROCESS OF GRINDING ABRASIVE ABOUT

Consider the impact of technological regimes polishing surface finish and establish the optimal conditions for grinding and abrasive wheels revision in view of their period of stability.

Keywords - quality, grinding, abrasive wheel, roughness, accuracy, stability, optimal mode, simulation, manufacturing software.

Statement of the problem. Current areas of manufacturing engineering involves extensive use of advanced technological processes of machining workpieces machine parts. Technological capabilities grinding process can be considered as a method to improve the efficiency of roughing and finishing machining operations. The advantage of the grinding process is high dimensional accuracy, about 2 - 4 мкm, machined surface roughness Ra = 1,25 ... 0,32 мкm.

To further improve performance grinding and expand its technological capabilities is the use of high-speed grinding, which is provided by increasing the speed of grinding wheel. In turn, requires a high-speed grinding abrasive wheels with high tensile strength, low imbalance and relevant cutting properties of the working surface [1, 2].

Technology provides preliminary grinding machining (edit) work surface abrasive wheel to create a certain relief and cutting properties, depending on the requirements of the grinding process and the quality of the machined surface. In the grinding process exacerbate abrasive wheel is not sufficient to perform the processing, because it is not stored geometry and parameters of its relief work surface. For most abrasive wheels Constraints their work is dimensional stability , recovery of which require periodic revision of forced treatment of the working surface , that the operation of forming a working surface profile of abrasive wheel. Therefore, the advantages of grinding can be realized most fully, as in the manufacture of high quality wheels and setting the frequency of the forced control of their relief work surface, which is especially important in terms of processing on automated equipment. Based on this approach, you can create different technological methods, which guarantee high processing performance and surface finish in grinding.

Analysis of recent research. Research devoted to the grinding process [3, 4, 5, 6 , 7, 8, 9 and others.], which laid the theoretical foundations and directions for further development of the theory of grinding. This work laid the beginning of the creation of fundamentally new methods of grinding, which are widely used in engineering industries. Most cited papers identified key requirements for the grinding process, which are reduced to improve performance and reduce the cost of treatment while improving the quality of the surface layer. The analysis of these studies shows that any unexpected violation of the process - Tool instability, deviations from the geometric accuracy of the size and shape of circles, etc results in the disruption in the process of grinding. Therefore, in order to improve the efficiency of the grinding process, conducted research aimed at providing technology reliability grinding, and related, among other issues, with the choice of instruments, modes of formation of its working surface and grinding.

The main factors that affect the quality of surface finish in grinding (surface roughness, accuracy, formation of thermal defects) can be divided into two groups. The first group should include technical condition of equipment, precision machine tools and debugging techniques, the characterization of abrasive wheels, grinding modes and quality coolant. Given that the stability of each of the following factors is lost gradually, they are not able to quickly change the results of the treatment. The second group of factors, the authors include cutting properties of the abrasive wheel and the ability to maintain the geometric parameters of cutting its relief work surface. These factors are more mobile, they are faster than the first, losing their original condition and often require intervention in the process of cutting and shaping grinding relief grinding wheel.

During grinding, under cutting forces and temperatures, as well as contact interaction, abrasive wheel wears loses its geometric shape and cutting properties. These effects lead to a deterioration of the treatment, increasing the surface roughness and waviness, there are thermal defects, reduces the intensity of cutting allowance. Especially uneven wear circle occurs when profile grinding cutting method where limiters work is dimensional stability. Changing the cutting properties displayed in the output parameters of the process of grinding. Therefore, an important technological characteristics of the process of conventional grinding abrasive wheel cutting is a continuous renewal properties and the desired geometric shape of circles work surface by forming a relief special tools.

The formation of the working surface relief cutting grinding wheels with conventional abrasives with mortise method for forming diamond rollers cases fair and precision grinding reviewed in [5, 9]. As a result of this research established mechanisms of cutting relief work surface abrasion wheel , especially the formation of ground surface roughness, terms of effective use of abrasive wheels for finishing operations and precision grinding.

On the basis of experimental dependences of the height of the machined surface irregularities on the duration of grinding, in [1] the expressions for the arithmetic mean deviation of the profile Ra for different processing conditions as a function of time grinding

$$Ra(\tau) = (Ra_n - Ra_c)e^{-\lambda\tau} + Ra_c e^{\delta\tau}\ , \tag{1}$$

where $Ra(\tau)$ - the arithmetic mean deviation of the profile over time τ (min) after the formation of the cutting grinding relief grinding wheel;

Ra_n - the arithmetic mean deviation of the profile at the beginning of grinding;

Ra_c - the arithmetic mean deviation of the profile after installation conditions circle - at the beginning of his hospital work;

δ - rate of the characterizing growth height inequalities due mild attitude and clogging of the circle and increasing the intensity of vibration in the grinding zone;

λ- degree index , which reflects the exponential character height reduction of inequalities due to wear of the circle in the first period of his work by the equation (1) is defined as

$$\lambda = ((Ra_n - Ra_c) + 3)/\tau_1\ ,$$

where τ_1 - the duration of the first period of the grinding wheel.

Thus, to determine the roughness of the ground surface detail under various conditions of treatment must have arithmetic mean deviation of the profile surface at the beginning of grinding, which depend on the technological parameters of the process of forming the cutting relief. In the same paper it is shown that the ratio Ra_n/Ra_c does not depend on the mode of grinding wheel and abrasive characteristics, and determined only as relief work surface grinding wheel, which is formed in the process of its diamond tools. Shown the dependency ratio Ra_n/Ra_c , I conclude that the grinding process may , depending on process parameters molding process to create a relief on the working surface of the abrasive wheel, which eliminates changing the roughness of the machined surface during polishing to form a relief that its working surface , which corresponds to the period fixed abrasive wheel work . For information about the possibility of practical implementation of this approach are given in [10] based on experimental studies of the influence of cutting conditions of formation of the relief grinding wheel for ceramic bond grinding roughness on the surface . The author of this process is called grinding with fine editing "circle". The method allows the grinding parts with machined surface roughness of Ra = 0.2 ... 0.4 microns in conventional grinding machines grit abrasive wheel 25 without the time consuming process of nursing. The essence of the method is that the decrease of the transverse and longitudinal feed of the diamond tool to create a homogeneous and uniform relief on the working surface of the circle, resulting in the ground to produce a significant reduction in the roughness of the ground surface.

The obtained results indicate that the formation of ground surface roughness is not a random process, and has a natural character, and, with an appropriate choice of technological parameters of the process of forming a relief cutting wheel abrasive diamond tools, we can provide a stable roughness of the machined surface within 90 ... 95% number of parts in the party with quenching and hardened steel without the use of nursing process. This approach will ensure a stable roughness of the machined surface from the start polishing process after the formation of the relief cutting abrasive wheel.

According to the author [4], abrasive wheel requires the formation of the relief in the event of loss of cutting properties, or when the maximum allowable value of the roughness of the machined surface. These parameters have significant impact method and technological conditions of the terrain wheels abrasive diamond tools. The work presented interesting results of comparative studies of the impact of the relief formation abrasion wheel sharp and blunt diamond crystals on the roughness of the machined surface under the same conditions of grinding. The experimental results showed that in the first minutes of grinding wheels of relief molded crystal sharp diamond machined surface roughness of 0.5 - 0.6 microns higher than in the case of forming a blunt diamond crystals. By [4] explains this pattern as the formation of the working surface of the abrasive wheel in the latter case "threaded" path with few sharp cutting edges and smoothing intensification plastic surface finish. This makes the achievement of initially low roughness grinding surface finish. As the gradual wear of the working surface of the abrasive wheel, machined surface roughness for both cases leveled. However, in grinding abrasive wheel, with the formation of diamond crystals sharp relief, lower roughness of the machined surface is kept at a much greater number of machined parts. That is, this can be sanded around 1.5 - 2 times longer than the round, relief which is formed with a blunt diamond crystals. In the latter case, abrasive cutting discs quickly losing properties.

Cost achieve the desired quality of the machined surface depends not only on methods of processing, it also changes in the middle of this method, depending on the cutting conditions. Such problems are solved using optimization principles that envisage the extreme values of some parameters and other constraints.

Formulation the purpose of article. Establishing optimal conditions for quality surface finish in grinding abrasive wheel. Determine the optimal mode grinding, allowing you to get the highest performance and lowest cost processing, providing the necessary tech-tech requirements for machine parts.

The main material. When grinding the main factors that limit the possibility of increasing the productivity achieve roughness of the machined surface is machine tool manufacturing capabilities and degree of cutting tool properties. It is known [11], the grinding processing performance can be determined from the dependence

$$П = \frac{1}{T_{шт}} = \frac{1}{T_{м} + T_{p}} = \frac{V_{д} S_{n}}{\pi d l} \left(\frac{1}{1 + \frac{T_{p}}{T_{м}}} \right), \qquad (2)$$

where $T_{шт}$ - artificial time, min.; $T_{м}$ - computer time to process, min.; T_{p} - manual time min.; $V_{д}$ - the speed of the workpiece, m / min.; S_{n} - feed in grinding, mm / rev ; d - diameter of the workpiece, mm; l - length of workpiece , mm.

Factor in parentheses examine the effect of time on the performance of hand- polishing process . If we accept the $T_{p}/T_{м}$ =const, then the specified assumption and a constant supply to a depth $T_{м}=V_{д}S_{n}/(\pi dl)$, performance can be represented area of the machined surface per unit time $T_{м}=V_{д}S_{n}$. Grinding machines allow speeds vary widely workpiece and traverse. There fore , the main limitation of the performance parameters of the process can take a cutting properties of grinding wheel and power looms, which has a significant impact speed of the grinding wheel.

The speed of the grinding wheel at work can not be less than that determined by the kinematics of the machine. However, given the fact that with an increase in speed of the grinding wheel decreases the load on the abrasive grain and, there fore , its operation [11, 12], the optimization of the grinding process should take a maximum speed wheel, which provides the technical capabilities of the machine tool , especially with the reduced and roughness of the machined surface. In this case, restrictions on capacity machines can be accomplished by one of the components of the regime grinding: grinding depth, traverse speed or workpiece.

Precision machining, as well as the roughness of the treated surface is a complex quality indicators that determine the performance properties of machine parts. Providing the required accuracy determines the structure of the process of manufacturing of machine parts and affects mainly the technology finish operations , which includes grinding. Therefore , the development of optimal technological modes of grinding necessary to ensure both the roughness of the surface finish and dimensional accuracy of details given .

The general balance of sources of error, the largest impact on the accuracy of the grinding surfaces are: malfunctioning installation of the grinding wheel and the technological system deformations. The impact of uncertainty on the grinding wheel installation accuracy is significantly reduced after editing a diamond tool.

The forces that occur during grinding , deforming technological system , and therefore the actual grinding depth ($t_{ф}$) is less than the nominal depth of grinding (t). If you do not consider the operation instrument lawfully do in finishing grinding [11, 12] , the difference Δt = t – $t_ф$, will largely determine precision grinding.

Errors Δt is calculated according to the method of grinding, fastening pieces and the relative position of the grinding wheel. Thus, when grinding with regard to the rigidity of the workpiece, the grinding depth deviation (Δt) is calculated from the dependence [1]:

$$\Delta t = P_y \left[0{,}25 \left(\frac{1}{J_{п.б}} + \frac{1}{J_{з.б}} \right) + \frac{1}{J_{ш.б}} + \frac{1}{J_д} \right], \qquad (3)$$

where $J_{п.б}$, $J_{з.б}$, $J_{ш.б}$, $J_д$ - respectively the rigidity of the front headstock, tailstock, headstock, and grinding the workpiece.

Workpiece hardness value is calculated from the dependence:

$$J_д = \frac{2{,}4 d^4 E}{l^3}, \qquad (4)$$

where d - diameter of workpiece, mm;

l - length of workpiece, mm;

E - modulus of elasticity of the material of the workpiece, MPa.

For example, when grinding the shaft diameter d = 50 mm and length L = 250 mm with a depth of grinding 0,015 mm traverse 24 mm / rev and speed of the workpiece 30 m / min, the error due to changes in the depth of grinding is 0.0025 mm, ie 17 %. Reducing the depth or speed grinding piece 3 times and 2.5 times feeding, reduces error about 2 times. But the biggest impact on the deviation of the depth of grinding workpiece having a diameter and its length. The value of the rigidity of the front , back and headstock grinding, for example have been calculated to take from [14]. Calculations show that in some cases the deviation grinding depth can be located at the level of tolerance for size or exceed it. Therefore, optimization of maintenance roughness of the machined surface must be performed taking into account the achievement of precision grinding.

When grinding going local heating of the metal surface layer of the workpiece, in some cases, the temperature in contact with the treated material grinding wheel can reach a maximum, at which the formation took place at the machined surface. The use of coolant virtually no effect on the temperature, which occurs in the contact zone of the workpiece with the grinding wheel , but removes heat from the surface layer and prevents the accumulation of heat in the workpiece and raise its temperature . Therefore , one of the measures to prevent the formation of thermal defects in grinding application to be considered when cutting coolant . Depending on the conditions of grinding, in [13] prompting recommendations for selecting coolants and their method of feeding into the grinding zone .

As shown in [13] , the temperature of grinding is not equally dependent on the mode constituents grinding. Ceteris paribus increase of the longitudinal flow and the peripheral speed of grinding workpiece temperature increases significantly in a smaller degree than by increasing the depth of grinding. Therefore, prevention of burning on the treated surface and limit the depth of grinding is treated with the maximum values of the longitudinal flow and the peripheral speed of the workpiece. The formation generally increases the burning rate of the ring workpiece. Therefore, in the optimization of the grinding process on the parameters of the machined surface roughness and dimensional accuracy, it is necessary to impose restrictions on grinding mode with check processing conditions under which it is possible to prevent the formation of burning on the treated surface.

In [15] proposed to restrict the power of the main drive the machine. According to the proposed regulations adopt the average value of power sanding, per 1 mm grinding wheel: a preliminary grinding - 0.12 - 0.18 kW; finish grinding - 0.08 - 0.12 kW; Finishing grinding - 0.04 - 0.07 kW.

Power of the main drive of the machine tool during grinding is determined from the dependence [12]

$$N = \frac{P_z V_k}{1000\eta}, \text{ кВт.} \qquad (5)$$

Mean power (Nc) for a given grinding conditions will be processing - Nc = N/B.

During grinding pieces of machinery parts, especially in automated manufacturing, to stabilize the process to ensure the quality of the machined surface, there is the problem of determining the frequency of execution of the revision of abrasive grinding wheel. Of course, the frequency of the correction process depends on the stability of the relief of the working surface of the grinding wheel to ensure, as the roughness of the machined surface and the polishing process performance. This parameter can be determined from the relationship (1) , based on the following conditions. To reduce friction between the grinding wheel and workpiece and to ensure their cooperation at the level of the height of the working surface topography of the circle need to cut a maximum thickness of grain (a_z) was less than the height of the relief (h_a), which in turn will be determined by the depth of edits (h_n), that $h_n > a_z$. Therefore, the height of roughness (Rz_n), which is formed at the beginning of grinding roughness can be taken by the relation (1), excluding nursing. According to relation (1) determine the future growth potential of the machined surface roughness, and the need to stop the process of grinding wheel revision and implementation. On the other hand we can choose a mode grinding wheel revision, which would exclude the first component in the relation (1) and reducing the time to ensure the machined surface roughness . That condition is the equality of the initial and final roughness, according to relationship (1). However, as shown in [1], time stability of abrasive wheels depends on the intensity of cutting metal. Mathematical processing of the experimental data allowed to obtain empirical dependence period of stability (C) abrasive wheel cutting metal on the intensity (G = 1 ... 10 sm^3/min) in grinding hardened steel quenching quenching and 45 grit circles 16, 25 and 40 and C1 hardness. When grinding steel quenching dependencies are as follows:

$$C_{16} = 166G^{-2,37} \times \frac{D_k}{300};\ C_{25} = 145G^{-2,25} \times \frac{D_k}{300};\ C_{40} = 117,7G^{-2} \times \frac{D_k}{300}. \quad (6)$$

When grinding hardened steel 45:

$$C_{16} = 85,8G^{-2,32} \times \frac{D_k}{300};\ C_{25} = 52,2G^{-2} \times \frac{D_k}{300};\ C_{40} = 40G^{-1,785} \times \frac{D_k}{300}. \quad (7)$$

Depending on the length of the workpiece, the dependence (6) and (7) to determine the number of machined workpieces during the period of stability of the grinding wheel and the frequency of operation corrections circle.

The intensity of metal cutting during grinding can be determined from the dependence [11]:

$$G = \pi \cdot d \cdot n_\partial \cdot t \cdot S_n, \text{ см}^3/\text{хв}. \quad (8)$$

When grinding for industrial technological regimes , the intensity of cutting allowance , mostly located within 10 sm^3/min and therefore we can assume that adopt modes satisfy the conditions of grinding cutting allowance for the dependence (6, 7).

The frequency of operation of the grinding wheel revision determined from the equations of normal time period for processing and stability of the grinding wheel. For example, when grinding the shaft diameter d = 50 mm, length L = 250 mm around 25 grit , speed parts n_d = 200 r/min traverse Sp = 20 mm/rev and a depth of 0.01 mm grinding , frequency (p) operation of the grinding wheel revision is determined by the relation (9):

$$П = 145G^{-2,25} \times \frac{D_k S_n n_\partial}{300L}, \text{ det.} \quad (9)$$

Regular time with is then T_o = 0.63 min, and the frequency of operation corrections - every 4 shaft. If the depth of grinding reduced to 0,005 mm, the frequency of revision surgery is 20 parts, which coincides well with the data presented in [12].

In most cases, when determining the optimal modes in order to optimize treatment should be getting minimum cost operation. In [12, 13] have shown that processing mode option that provides the smallest piece while at the same time is also the most economical option. Therefore, as a basis for optimization of grinding advisable to take to achieve the highest performance of the process, while ensuring the necessary roughness of the machined surface.

The main specifications for mechanical processing, provided for the designer in the design drawings of parts is machined surface roughness and dimensional accuracy. During machining, apart from the roughness of the machined surface , it is necessary and appropriate to achieve dimensional accuracy , which in turn depend on the regimes of the revision of the grinding wheel and grinding. Therefore, the value of the mode adopted for the initial factors as security roughness surface finish and precision handling.

The problem of determining the best mode of grinding to ensure the quality of the machined surface is performed in the following order:

necessary to make the equations that define the technical limitations of the regime grinding capabilities for grinding machines;

establish the mathematical form of the function that determines the goal of optimization;

mutual consideration of technical constraints and functions and definitions on this based on the best mode of grinding.

To ensure the machined surface roughness and dimensional accuracy , to change the values of technological factors editing and polishing processes should provide the following limitations:

a) the roughness of the machined surface - $R_z^* \geq R_z(S, t, S_n, V_\partial, V_k)$; where R_z^* - the roughness of the workpiece surface , which provides the technical specifications;

b) the accuracy of the details - δ * ≥ δ; where δ * - Admission to the size of the part , δ - errors that are associated elastic deformations of the technological system;

c) for power sanding of conditions preventing the formation prypalyv on the treated surface;

d) for filing in tetanus ratio to the width of the contact of diamond crystals from the working surface of the grinding wheel with the condition of continuity correction process circle $S \leq 2t_n \cdot tg(\gamma_a / 2)$ - where t_n - depth revision of the grinding wheel;

e) frequency spindle grinding machines - $n_{\max} \geq \frac{1000V_k}{\pi D_k} \geq n_{\min}$; where n_{max} and n_{min} - the highest and the lowest frequency spindle grinding machines;

g) the frequency of rotation of the workpiece - $n_{\max}^* \geq \frac{1000V_\partial}{\pi d} \geq n_{\min}^*$; where $n_{\max}^*$ and $n_{\min}^*$ - the largest and most lower frequency of rotation of the workpiece parts according grinding machines;

f) to traverse - $S_{max} \geq S \geq S_{min}$, where S_{max} and S_{min} - the largest and the smallest supply according grinding machines;

k) the power to drive the grinding wheel - where ηv - the efficiency of the grinding wheel drive mechanism [12]. The value of the tangential component of the grinding force is determined by the empirical equation - $P_z = C_{Pz} V_\partial^{0,7} S_n^{0,7} t^{0,6}$, where C_{Pz} - coefficient characterizing the workpiece material and other conditions of grinding. This factor of 22 to take a hardened steel; 21 for non- hardened and 20 - to iron.

Conclusion. Based on the analysis of the literature revealed that research on the impact of technological factors grinding process on the performance quality of the finished surface during polishing, but establish the optimal conditions for grinding is carried out. Therefore, the proposed method of determining the range of technological regimes grinding, abrasive wheel straightening and its frequency performance can provide the required parameters of quality grinding and increase productivity and reduce the cost of processing.

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