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ON THE INFLUENCE OF OPERATING CHARACTERISTICS OF GRINDED WHEELS ON THE QUALITY INDICATORS OF GRINDED PARTS

The quality of the surfaces of roller bearing parts is formed in the process of interaction of the cutting tool with the surfaces to be treated. In addition to technological factors, a significant place in providing a quality surface layer is occupied by the correct choice of grinding wheels.

The abrasive tool has different properties depending on its characteristics. When choosing an abrasive tool, it is necessary to take into account its characteristics and their suitability for a particular type of work. Stable operation of abrasive wheels depends on the correct choice of their size, characteristics and modes of operation.

The selection of grinding wheels depends on the type and properties of machined materials, power of grinding machines, spindle speed, grinding mode, requirements for accuracy and surface cleanliness and other factors that apply to the workpieces.

Depending on the accuracy requirements for machining parts made of different materials, the characteristics of abrasive wheels are selected, the main of which are hardness, grain size, bond, structure, shape, size and allowable speed.

Keywords: *granularity, grain material, hardness, grinding, tool.*

Introduction. In the technological cycle of bearing production the leading place is occupied by grinding operations of processing of surfaces of details of roller bearings. If the processes of manufacturing rolling elements consist of procurement processes and abrasive machining operations, the technological process of manufacturing bearing rings consists of procurement, turning and a number of grinding and finishing operations of abrasive machining.

The main content. Bearing manufacturing technology is a complex production process that consists of a number of basic and auxiliary operations [8]. For automated readjustment production, the typical structure of manufacturing technology remains virtually unchanged, but the technological modes, equipment, tooling are constantly changing [5], and this requires operational design and technological training.

Due to the complexity and the above features of the technological process [3], the enterprises for the manufacture of bearings operate flexible automated production [7]. Such productions include at least three main subsystems: a flexible automated production complex of the main production, a flexible automated system of technological preparation of production and an automated system of operational management, including the processes of its preparation and readjustment [8].

According to this concept, automated technological complexes (ATC) are created in production - functionally interconnected sets of automated process control system and technological object of control [5]. Flexible ATCs are built, as a rule, on a modular principle: they consist of a group of interacting modules of varying complexity, having a common coordinating control for both basic technological operations and for operations of transportation, warehousing, etc. [8].

The principles of construction and operation of automated readjustment production are based on the basic provisions of the theory of hierarchical multilevel systems, vertical decomposition with priority of external subsystems [6, 8]. These principles are complemented by the use of horizontal (aggregate) decomposition of objects and control subsystems at each level, which allows by organizing an iterative process to synthesize both individual elements and subsystems, and the production system as a whole.

A multi-layered hierarchy of solutions (levels of complexity) and organizational hierarchy are effectively used for system analysis.

An important place in automated technological complexes is occupied by control and measurement of parameters at all levels [4]. To ensure product quality, there is a need to sharply increase the level of technological accuracy, which requires further development of management and regulation, ie comprehensive development of active control, which is one of the effective methods of technological quality assurance [8].

Research results. . Productivity and quality of grinding depends not only on the width of the wheel and its diameter, but also on the parameters that characterize the abrasive tool. One of the most important characteristics of an abrasive tool is the grain size (grain size) of the abrasive. Depending on the grain size, abrasives are numbered. Coarse-grained (2000 - 160 microns) have numbers from 200 to 16, they are called grinding grains. Smaller, with a grain size of 125 - 28 µm (grinding powders), denoted by numbers from 12 to 3. Micropowders with a grain size of 40 to 3 µm are denoted by numbers from M40 to M5.

Table 1.

Characteristics of grinding wheels

Grain material	Grit	Hardness	Structure	Connection
electrocorundum normal (12A, 13A, 14A, 15A)	200-125 grinding grain	Extremely hard (NT), fairly hard (DT)	1-4	ceramic (K)
electrocorundum normal (12A, 13A, 14A, 15A)	100-32 grinding grain	medium hardness (ST) (CT1, CT2, CT3)	5-6	ceramic (K) bakelite (B)
electrocorundum white (22A, 23A, 24A, 25A)	25-16 grinding grain	medium hardness (ST) (ST1- ST3)	7-8	ceramic (K) bakelite (B)

The structure of the abrasive tool is evaluated by the ratio (in%) of the volumes occupied by the abrasive grains, binder and pores. By changing these ratios, abrasive wheels of different structure and properties are obtained. There are 12 numbers of structures. The lowest number of porosities (60% grains, 40% ligaments and pores) corresponds to the largest number.

The type of grinding wheels is also characterized by the shape. Thus, the circles of the straight profile denote PP.

An important characteristic of the abrasive tool is also a binder (inorganic, organic, metallic), which unites the abrasive grains into a single whole. In practice, the tool is widely used using an inorganic binder based on refractory clay - ceramic (K), based on synthetic resin - bakelite (B), rubber and sulfur - volcanic (B). Metal binders consist of a metal base (powders Al, Cu and others) and a filler. They are used mainly in diamond wheels.

Another parameter that characterizes the abrasive tool is its hardness. This indicator determines the resistance of the binder to the removal of abrasive grains under the action of external forces. A scale has been developed that has seven hardness classes (they are also divided into several degrees): T - hard, ST - medium hardness, DT - very hard.

The high hardness of the grinding wheel is one of the causes of scorching of the surface layer of the bearing rings, which is not allowed by the technical conditions. Therefore, the grinding wheel after its selection is checked for hardness by one of the methods:acoustic (GOST 25961-83); sandblasting (GOST 18118-79); indentation of the ball (GOST 19202-80).

Promising areas in the field of grinding, which reduce the energy consumption of processing, increase productivity, as well as improve the surface layer of parts made of the above materials and, consequently, increase their life, is the use of intermittent and electroabrasive grinding.

Intermittent grinding wheels show the advantage of these grinding processes in terms of specific energy consumption, stability, preservation of cutting ability.

Grinding wheels with an intermittent cutting surface can be divided into intermittent, composite and combined. Working surface of intermittent grinding wheels developed by Yakimov OV made in the form of alternating cutting protrusions and depressions.

Based on them, it is possible to assess the effectiveness of the implementation of technological measures in the operations of mechanical abrasive processing.

One way to reduce the heat stress of the grinding process is to use wheels with low hardness. Such circles work in the mode of self-sharpening, but have a large dimensional wear, which leads to an increase in the time spent on editing the circle. Increasing the hardness of the wheel leads to the fact that the wheel operates in a constant blunting mode, which on the one hand leads to a decrease in surface roughness [4], and on the other hand to increase the tangential cutting force during grain wear and, consequently, to increase temperature in the cutting zone [6, 7, 8]. The advantage of grinding wheels of greater hardness is their high dimensional stability, which is a necessary condition during machining with high accuracy. It is necessary to develop measures

The material of the abrasive grain, the hardness and bond of the wheel depend on the material of the workpiece, its hardness, as well as the speed of rotation of the wheel. The grain size of the circle depends on the regulated parameters of the surface roughness. Liquid medium, solid lubricant or ZOR in the form of an aerosol can be used as ZOR during grinding. The choice of type and brand of ZOR is carried out in accordance with the recommendations given in the reference literature [6]. However, it should be noted that no matter how effective ZOR is used, it does not completely solve the problem of providing grinding without annealing [8, 9].

According to the general equation of the grinding process

$$s_p = s_d + s_\kappa + s_{\mathrm{pd}}, \qquad (1)$$

where SPD is the magnitude of the elastic deformations of the system.

Based on the methods of the theory of automatic control [3] using transfer functions, the transfer function of an open system, the initial value of which is the removal of the allowance sd:

$$W_p(p) = \frac{s_d(p)}{s_p(p)} = \frac{W_1(p)W_4(p)W_5(p)}{1+W_1(p)W_2(p)W_3(p)} = \frac{\kappa_1\kappa_3\frac{1}{p}}{1+\kappa_1\kappa_2\frac{1}{p}} = \frac{\kappa_p}{1+T_p p}, \qquad (2)$$

where $\kappa_p = \kappa_3/\kappa_2$ - transmission coefficient of the open system of the object;

$T_p = 1/\kappa_1\kappa_2$ - time constant of the open system of the object.

The transfer function of a closed system of the control object

$$W_{\text{зм}}(p) = \frac{W_p(p)}{1+W_p(p)} = \frac{\kappa_{\text{zм}}}{1+T_{\text{zм}}p}, \qquad (3)$$

where $\kappa_{z м} = \kappa_p/(1+\kappa_p) = \kappa_3/(\kappa_2+\kappa_3)$ - transmission coefficient of a closed system of the object;

$T_{z м} = T_p/(1+\kappa_p) = 1/[\kappa_1(\kappa_2+\kappa_3)]$- time constant of a closed system of the object.

Thus, the transfer function of the control object for grinding the inelastic part corresponds to the aperiodic link with a time constant Tzm and a transfer coefficient kzm.

Cutting tool - the grinding wheel has an independent drive. For internal grinding machines, this is usually a spindle - a motor that provides a high speed with minimal vibration. The circle is mounted on a frame, which is installed in the spindle and provides rotational movement and rectilinear movement along the axis. In addition, the spindle can move at different speeds in the transverse direction.

The grinding wheel is inserted into the hole of the ring, has a speed of approximately 20 - 80 thousand rpm and during grinding makes rectilinear movements back and forth (oscillates) along the axis of the ring by an amount of approximately 2 - 6 mm. Grinding can be performed in two modes: mortise grinding - the grinding wheel is forced to feed in the direction of the grinding surface [1], and care - the grinding wheel is not fed to the grinding surface by transverse feed, and grinding is due to stress equalization in the process system arose during mortise grinding. Accordingly, grinding in the mode of care is in the nature of a "damping" process and after some time stops. According to the amount of feed mortise grinding is divided into rough and clean [9].

Characteristics of centerless grinding are shown in table 2.

Table 2

Grinding modes and operation time

№ p / p	Grinding mode	Symbol.	One dimension.
1	part rotation speed	*Vdet*	m / min
2	part speed	*ndet*	rpm
3	speed of rotation of the circle	*Vš.kr.*	m / s
4	speed of rotation of the circle	*нш.кр.*	rpm
5	number of double moves	*ndv.h.*	dw./min
6	the magnitude of the oscillation	*Lost*	mm
7	forced feed	*Force*	mm / min
8	draft feed	*Black.*	mm / min
9	clean feed	*Clean.*	mm / min
10	time for surgery	*Top*	with
11	total cycle time	*Tc*	with

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Based on the calculation and analytical method proposed by AP Sokolovsky and later developed in [7, 9] it is possible to pre-determine the amount of error that the part will have after machining. The method consists in determining the individual components of errors that depend on certain factors and their sum. The calculation takes into account the following factors that cause the corresponding errors: geometric inaccuracy of the machine (Δ1), wear of the cutting tool (Δ2), thermal deformation of the technological system (Δ3), elastic deformation of the technological system (Δ4), inaccuracy of machine adjustment (Δ5), ie determining systematic components of error.

The magnitude of the total error is generally defined as $\Delta_{\mathrm{am}} = \Delta_c + \Delta_{\mathrm{sl}}$, where Δs is the algebraic sum of systematic errors; $\Delta_{CL} = \sqrt{(\Delta_{sl1})^2 + (\Delta_{sl2})^2 + (\Delta_{sl3})^2}$ - random errors determined by the uneven hardness of the material of the part (Δsl1), inaccuracy of measurements (Δsl2), variable allowance of the material of the part (Δsl3).

When summing up the errors it is necessary to take into account the type of production: single, small-scale, serial and mass. In single and small-scale productions it is necessary to consider only systematic errors (Δ_c), because machining in the conditions of such production has a number of features and the size-force factors influencing exact characteristics of details acquire essential value. The nature of production in most modern industries can be attributed to small-scale, so the magnitude of the total error can be defined as

$$\Delta_{\mathrm{am}} = \Delta_1 + \Delta_2 + \Delta_3 + \Delta_4 + \Delta_4 + \Delta_5 + \Delta_6, \quad (4)$$

where Δ_6 - error from the gyroscopic effect.

When processing on equipment in which the stiffness of the front and rear headstock are close to each other, the error of the gyroscopic effect can be ignored, because it is close to zero.

The error defined by expression (1) is the error of the shape of the part. The geometric error represents the difference in the corresponding dimensions of the same part due to the drawing, and is included as an integral part of the total processing error and is the predominant part of 50-70% [1, 2, 3].

The technological process of grinding has a number of significant differences from the processes of cutting with a blade tool: the chaotic location and variety of a huge number of small grains on the working surface of the circle; intermittent cutting edge at the grinding wheel; irregular geometric shape of abrasive grains and the presence of rounded vertices, forming negative front cutting angles from 40 ° to 150 °; high hardness, sharpness, fragility and heat resistance of abrasive grains; the dynamic effect of each grain on the treated surface layer; high degree of heating of the processed material and shavings; high speed and small depth of cutting; dispersion (grinding) of shavings is accompanied by considerable expenses of energy for overcoming of friction (in 4-5 times more, than at milling and in 12-15 times more, than at turning).

These features affect the accuracy of processing, roughness and physical and mechanical properties of the surface layer of the metal, determine the method of analysis and research of grinding processes.

In the works [7, 11, fig. 1] grinding is considered as a process of mass very thin high-speed microcutting by individual grains of the grinding wheel. The chips are removed by a single grain in 10-4-10-5 s, ie almost instantly. Abrasive grains have different shapes and sizes, located chaotically on the periphery of the circle with different depths. Each grain cuts a groove in the metal, which corresponds to the size and shape of its protruding part. This causes the appearance of longitudinal surface irregularities, representing a set of randomly arranged protrusions and depressions. The alignment of irregularities occurs when the set of abrasive grains approaches a continuous cutting blade, which occurs when increasing the speed of the circle Vk, reducing the speed of the part Vd and longitudinal feed Spr, reducing the grain size.

The decisive influence of technological parameters of working surfaces on operational properties is noted in works [1, 3, 7, 11]. For example, the presence of ripples reduces the reference area of the contact surface by 5-10 times compared to the same surface, which has only micro-roughness (roughness).

Fig.1. Working space and elements of the SASL-5D grinder

Conclusions. This paper presents theoretical and experimental studies of the dynamics of the process of intermittent grinding, in order to develop methods for selecting geometric parameters of wheels and modes of intermittent grinding for centerless circular grinding machines (mod. SASL 5D, SASL 5AD SASL125 / 1, SASL 200, etc.). A number of studies of the process of intermittent grinding were carried out and part of the general problem of improving the quality of the surfaces of the parts of the roller bearings being ground was solved. Rolling bearings as transmission elements in mechanisms for various purposes are characterized by a number of quality indicators that determine their performance properties, one of which is the accuracy and quality of rotational transmission, as well as the accuracy of fittings in connections with other elements of mechanisms.

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ПРО ВПЛИВ ЕКСПЛУАТАЦІЙНИХ ХАРАКТЕРИСТИК ШЛІФОВАНИХ КРУГІВ НА ПОКАЗНИКИ ЯКОСТІ ДЕТАЛЕЙ, ЩО ШЛІФУЮТЬСЯ

Якість поверхонь деталей роликопідшипників формується в процесі взаємодії різального інструменту з поверхнями, які підлягають обробленню. Окрім технологічних чинників, значне місце в забезпечені якісного поверхневого шару, посідає правильний вибір шліфувальних кругів.

Абразивний інструмент володіє різними властивостями залежно від його характеристик. При виборі абразивного інструменту необхідно враховувати його характеристики і відповідність їх для конкретного виду робіт. Стабільна робота абразивних кругів залежить від правильного вибору їх розмірів, характеристики і режимів роботи.

Підбір шліфувальних кругів залежить від виду і властивостей оброблюваних матеріалів, потужності шліфувальних машин, частоти обертання шпинделя, режиму шліфування, вимог до точності та чистоти поверхні й інших факторів, які висуваються до оброблюваних деталей.

У залежності від вимог точності до оброблення деталей з різних матеріалів підбираються характеристики абразивних кругів, основними з яких є твердість, зернистість, зв'язка, структура, форма, розміри і допустима швидкість обертання.

Ключові слова: *зернистість, матеріал зерна, твердість,шліфування, інструмент.*

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О ВЛИЯНИИ ЭКСПЛУАТАЦИОННЫЕ ХАРАКТЕРИСТИКИ ШЛИФОВАННЫЙ КРУГОВ НА ПОКАЗАТЕЛИ КАЧЕСТВА ДЕТАЛЕЙ, ЧТО ШЛИФУЮТСЯ

Качество поверхностей деталей роликоподшипников формируется в процессе взаимодействия инструмента с поверхностями, которые подлежат обработке. Кроме технологических факторов, значительное место в обеспечении качественного поверхностного слоя, занимает правильный выбор шлифовальных кругов.

Абразивный инструмент обладает различными свойствами в зависимости от его характеристик. При выборе абразивного инструмента необходимо учитывать его характеристики и соответствие их для конкретного вида работ. Стабильная работа абразивных кругов зависит от правильного выбора их размеров, характеристики и режимов работы.

Подбор шлифовальных кругов зависит от вида и свойств обрабатываемых материалов, мощности шлифовальных машин, частоты вращения шпинделя, режима шлифовки, требований к точности и чистоты поверхности и других факторов, которые предъявляются к обрабатываемых деталей.

В зависимости от требований точности до обработки деталей из различных материалов подбираются характеристики абразивных кругов, основными из которых являются твердость, зернистость, связи, структура, форма, размеры и допустимая скорость вращения.

Ключевые слова: *зернистость, материал зерна, твердость, шлифовка, инструмент.*