Ministry of Education and Science of Ukraine
Ternopil National Technical University named after. I. Puluj
Department of Mechanical Engineering Technology

Synopsis of lectures on the subject "Operation and maintenance of machines" for students of all forms of study

Direction of preparation 131 " Applied mechanics"

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Mechanical Engineering
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INTRODUCTION

1. BASIC TERMS AND CONCEPTS USED IN TECHNOLOGICAL MAINTENANCE

1.1 Introduction

The development of the machine-building industry involves the widespread introduction of new types of machines and process equipment with high technical and economic indicators that can provide high productivity, a significant level of automation of technological processes, as well as rapid adjustment to various technological cycles.

It is known that the efficiency and technological returns of equipment are determined not only by its technical characteristics, but also by the large-scale and rational exploitation of this equipment.

Exploitation of the machine is a complex process consisting of different periods during which the efficiency of the machine is reduced or restored.

At enterprises of machine-building in exploitation there is a large quantity of various technological equipment.

Manufacturers of equipment that is exploited include dozens of enterprises in Ukraine and foreign companies.

Simultaneous exploitation of equipment of various technological purposes and different manufacturers is determined by the absence of common industry regulations for its exploitation and maintenance.

Another external factor that determines the tendency to operate and maintain is to increase the technical and operational characteristics of equipment (productivity, capacity, etc.) due to its structural complication.

Experience has shown that the increase in maintenance costs (in proportion to the increase in the price of the equipment being implemented) outstrips the growth of production volumes.

It is also established that over the entire period of operation of the equipment maintenance and repair costs due to the loss of performance during operation, as a rule, several times, and sometimes in order, are higher than the price of this equipment.

The most important characteristic of the equipment used in the field is its "age" composition. The analysis of the terms of the service equipment of the machine-building industry indicates the presence of a large proportion of physically worn equipment.

This led to the accumulation of physically depreciated equipment. As a result, support for equipment in working condition, including maintenance and repair, accounts for approximately 75% of all costs, of which 20% is spent on equipment to be written off.

Thus, maintenance costs depend on the length of operation of the equipment and the process of changing the physically worn out equipment to the new one.

The reasons for the growth of the role of service maintenance equipment at enterprises are also conditioned:

1 further displacement of manual labor, which leads to an increase in the number of serviced machinery, machines, devices, automation and robotics;

2 increase in costs for every hour of idle time, the reduction of which is achieved by reducing the number of failures due to preventive work and reducing the duration of the elimination of the reasons for refusals;

3 lack of branded service of imported equipment;

4 the necessity of manufacturing mechanization equipment, non-standard devices and technological equipment.

Considerable attention is paid to technical maintenance in developed countries. In the United States, repair and maintenance personnel usually consist of the most highly skilled workers who have at least four years of professional training. A. Champen, head of the service department of the Ford Motor Company organization, wrote: "Until recently, due diligence was not given to improving the organization of repairs and maintenance of equipment. Now, the administration of enterprises is inclined to think that repairs and servicing have become a "big business" with the possibility of generating significant income. "

Thus, the qualitative training of graduates of higher educational institutions of mechanical specialties on issues of ensuring the reliability of equipment at all stages of its existence (design-manufacturing-operation-repair-write-off), especially on the issues of operation is relevant.

The subject of the course is the question of maintaining a capable state (workability) of equipment during its operation, in which it is able to perform the assigned functions, while preserving the value of the output parameters within the limits set in the normative and technical documentation. Such parameters can be: productivity, power, traction ability, speed characteristics, work process parameters, and more.

The science of the operation and maintenance of machines examines the laws and methods of efficient use of the park of cars.

It takes into account the factors that affect the performance of machines, examines the methods for their determination, and examines the systems of maintenance and their organization, as well as the principles of the formation of a rational fleet of cars.

The objective of the course is to study the basic provisions of rational exploitation and maintenance of technological equipment for the effective use of their (provisions) in the practical activities of specialists.

The operation and maintenance of machines is an applied discipline, which is intended, first of all, for the mechanics who operate the existing equipment. A number of provisions are needed in the preparation of new design engineers. Theoretical basis of the science of operation and maintenance of machines. The science of the operation and maintenance of machines is based on knowledge of the structure and principles of machines, material resistance, material science, theory of reliability, probability theory, which is used to process data of observations on the work of this type of machine, as well as the system of standards regulating the procedure for collecting information, forms and methods of evaluation of operational information, methods of statistical processing of information,

1.2 Basic terms and concepts used in technological servicing. Product quality, product reliability

An integrated, generalizing property of any product, taking into account technological equipment, is quality. The science of studying the quality of products is called qualimetry.

Quality determines the set of product properties that are determined by its suitability to meet certain needs in accordance with the purpose.

The quality of any product is characterized by a number of properties, which are referred to in the "Technical Data Sheet and Product Quality".

Main basic indicators of quality include the following:

- indicators of functional and technical efficiency (productivity, power consumption, technological speed, etc.);
- constructive indicators (overall dimensions, occupied area, weight, etc.);
- indicators of composition and structure (indicate the specifics of products).

Reliability Indicators:

- indicators of longevity;
- maintenance rates;
- conservation values.

Economic indicators (indicate the economic use of materials, energy, fuel, labor resources). These include productivity per unit of occupied space; electricity consumption per unit of output, specific labor intensity of production, coefficient of material resources uses, etc.

Indicators of productivity. This is a complexity factor, specific material consumption, labor-intensive manufacturing, etc.

Indicators of standardization, unification and interchangeability, namely: coefficient of applicability on standard sizes in percentages and coefficient of repeatability in percentages, coefficient of interdepartmental unification, etc.

Ergonomic (physiological and hygienic) indicators. This is the noise level (in dB), the level of vibration (in dB), the convenience of working positions (determined by distance from floor to service areas), equipment compliance with human strength, harmful effects of equipment in the form of harmful emissions, radiation, etc.

Quality is also characterized by indicators of safety, technical aesthetics, ability to transport, transportability, patent and legal indicators, etc.

The nomenclature of the main indicators of the quality of equipment of the same designation allows:

- to evaluate and compare the technical level and quality of the projected equipment with the operating;
- characterize the prospects for the development of this group of equipment in the projected period;
- assess the impact of new technical solutions on the quality of products.

1.3 Basic concepts and definition of machine operation

Operation of a machine is a system of organizational, technical, technological and other measures that are carried out in the operation of machines.

Distinguish industrial exploitation (use) and technical exploitation.

Industrial exploitation is the period (stage of operation), during which the machines perform their inherent functions. This is a set of organizational, technical, technological and other measures aimed at ensuring the performance of the machine work. Industrial exploitation includes the assembly of machinery and the organization of its work, the technology in which this machine is used, as well as the management of its work.

Technical exploitation is the period (stage of operation), during which, due to a set of organizational, technical, technological and other measures, the maintenance of machines in an efficient, working condition is carried out. Technical operation includes acceptance, transportation, dressing, putting into operation, preventive maintenance, storage, maintenance, refueling and provision of machinery with materials and spare parts.

Performance and reliability of products during operation.

Performance is the state of the machine at which it is able to perform the specified functions, keeping the values of the specified parameters within the limits set in the normative and technical documentation.

Parameters can characterize the various properties of the machine depending on its purpose and the requirements that are put forward to it. These may be indicators of the accuracy of functioning, mechanical characteristics, kinematic and dynamic parameters, economic indicators, etc.

Failure is an event that involves disrupting the machine's performance.

Any refusal may occur after a certain period of time, which is a random variable.

For most machines for estimation of disability use the duration or corresponding volume of work performed (number of cycles, path, productivity). The machine's operating time to the failure expressed in hours is called run-to- failure.

One of the main attributes of the quality of technological equipment is its reliability, which manifests itself in the process of operation.

Reliability is the property of the machine to maintain its ability to work in time. Reliability is a generalized feature that includes the concept of reliability and durability.

Faultlessness - a property of the machine continuously remains operational during a certain period of time or working hours.

Durability is the property of the machine to maintain efficiency during the entire period of operation with the established system of maintenance and repair.

Insufficient equipment reliability leads to significant maintenance and repair costs, simple equipment, and material and labor costs.

The basic concepts and terms used in the theory of reliability are standardized.

Equipment, as an object of study of reliability, has three states: performance, serviceability and malfunction.

Damage is an event that involves disturbing the serviceability of an object while maintaining its ability to work.

Maintenance - a property that characterizes the product's adaptation to prevent and identify the causes of failure and damage, adaptation to maintenance and restoration of performance through maintenance and repair.

The importance of equipment maintenance is determined by the fact that with the structural complication of equipment it is increasingly difficult to find the elements that were rejected and the reasons for their failure. For example, in complex electro-hydraulic systems of machines, the search for the causes of failures can take more than 50% of the total recovery time.

Preservation - the property of the equipment to maintain the values of indicators of reliability, durability and maintainability during its storage and transportation.\

1.4 Indices of reliability and durability assessment. Quantitative reliability indicators

The given terms, which characterize certain properties of equipment reliability, give a qualitative idea about reliability. Quantitative reliability estimates are determined by reliability indicators, which are, accordingly, divided into four groups.

Indicators of reliability. The main ones are: the probability of failure-free operation, the average time to failure, the intensity and the parameter of the flow of failures.

The probability of failure-free operation. The main indicator of machine failure is the probability of failure-free operation of P (t) - this is the probability that in a given time interval t = T (or run-time), the machine failure will not occur.

$$0 \le P \le 1,$$

where P = 0.95 - conventional machines

P = 0,9999 - responsible products of emergency equipment

The statistical expression of this parameter when it is determined according to the experimental data is as follows:

$$P(t) = \frac{N(t)}{N(0)}$$

or

$$P(t) = \frac{N(0) - n(t)}{N(0)} = 1 - \frac{n(t)}{N(t)} = 1 - Q(t),$$

where N (t), N (0) - the number of good products at time t and the initial time t = 0;

(t) - the number of products that were rejected by the time t;

Q (t) - probability of failure.

The probability of failure-free operation, which is determined by the experimental data, is equal to the ratio of the number of products that have worked without fail until the time t, to the number of products that were operational at the 1initial time t = 0.

Indicator P (t) is also called the empirical function of reliability or frequency.

The mean time to failure is a measure of the reliability of non-recurring products, which is equal to the average value of the product's performance of a given batch prior to failure:

$$T_0 = \frac{\sum_{I=1}^{n_1} T_i}{n_1},$$

where T_i is the occasional time of operation of the product and the refusal;
n_1 is the number of batches that were rejected during the duration of the experiment.

The average failure rate is an indicator of the reliability of the recovery of products, which is equal to the average value of the product between two adjacent failures:

$$T = \frac{\sum_{i=1}^{n} T_i}{n},$$

where T_i - random operation of the product between two failures;

n - the number of failures of the product during the duration of the experiment

Failure rate is the reliability index of non-recurring products, which is equal to the ratio of the number of products that were rejected per unit time to the number of products that remained in service:

$$\lambda(t) = \frac{n(t+\Delta t) - n(t)}{N(t)\Delta t}$$

or

$$\lambda(t) = \frac{N(t) - N(t+\Delta t)}{N(t)\Delta t},$$

where *N (t), N (t + Δ t)* - the number of products that proved to be usable at time *t* and *t + Δ t*;

n (t), n (t + Δ t) - similarly the number of products refused.

The failure parameter Ω (t) is the reliability index of recoverable products, which is the ratio of the number of products rejected per unit time to the number of products being investigated, provided that all rejected products are replaced by the correct ones:

$$\Omega(t) = \frac{n(t+\Delta t) - n(t)}{N \cdot \Delta t},$$

where *N* is the number of studied parts.

Indicators of durability. The main ones include the service life and the type of technical equipment resource.

The main indicator of machine durability is its service life or work-up until failure of *T*.

The value of *T* is determined by the maximum permissible value of the initial parameter $X = X_{max}$ and by a certain random process of loss of machine performance.

Term of service TOS is called the calendar operation duration of the equipment to the limiting state. It is determined, as a rule, in years.

Technical resource (abbreviated, resource) T_r is the sum of the intervals of the fail-safe operation of the equipment to the limit state. The resource is defined in units of time of work (usually in hours), length of a way (for example, cars in km) and units of output.

For non-renewable products, the concept of resource and work-outs to failure coincide, because for them the failure and the boundary condition arise simultaneously.

The indicators of longevity are divided according to average, average to current (average or capital) repairs, average to write-off, g-percent, g-percentage are indicators that have or exceed the average number of (g) percent of equipment of this type.

Indicators of serviceability. The most commonly used average time, intensity and probability of recovery.

The average recovery time of Tv is equal to the average time of the forced downtime required to locate and eliminate one refusal:

$$T_в = \frac{\sum_{j=1}^{n} \tau_j}{n},$$

where t_j - random time of finding and eliminating j-th refusal;

n - number of failures.

The time tj is defined as the total length of the operations of finding the place and determining the cause of failure *t1*, troubleshooting t_i2, testing equipment after recovery t_j3 and preparation for the elimination of t4 failures (time of organizational measures).

Recovery intensity is the number of restorations per unit time, determined by the experimental data by the expression:

$$\mu(t) = \frac{\Delta m}{(N - m)\Delta\tau},$$

where N is the total number of products under surveillance;

Δ m, m - the number of products that are restored at intervals of time *Δ t* and *t*, respectively.

Under the probability of recovery, understand the probability of events, which consists in the fact that the performance of the object is restored within the set time ti:

$$\upsilon(\tau) = P\ (\tau \le \tau_i).$$

The main indicators of conservation include average and percentile terms of conservation capability.

The indicated reliability indicators characterize the individual properties of the object. The complex includes readiness and technical usage ratios:

$$K_Г = \frac{T}{T + Tв} \quad \text{and} \quad K_{ТВ} = \frac{T}{T + T_в + T_{пр}}$$

or

$$K_{ТВ} = \frac{\sum_{\mu=1}^{n} T_\mu}{\sum_{\mu=1}^{n} T_\mu + \sum_{j=1}^{n} \tau_j + \sum_{k=1}^{m} t_k},$$

where $T_{пр}$ – is the average time for implementation of planned preventive measures;

t_k - random time of k-th prevention;

m - the number of prophylactics in the interval of time during which the object was observed.

1.5 Peculiarities of the influence of various factors on the working capacity of machines

In the course of operation of the machine, there are various factors that can lead to changes in the parameters of the machine.

There are three main sources of influence:

- the energy of the environment, including the person performing the functions of the operator or repairman;

- internal sources of energy, connected both with the work processes that occur in the car, and with the work of individual elements of the machine;

- the potential energy accumulated in the materials and parts of the machine in the process of their manufacture (internal stresses in castings, installation stresses).

When working on the machine there are the following types of energy that affect its performance:

- mechanical energy, which is determined by the nature of the work process;
- thermal energy;
- chemical energy;
- nuclear energy;
- electromagnetic energy;
- biological factors.

2. EQUIPMENT FAIURES

2.1 Damage

Permissible and inadmissible types of damage.

Types of damage to machine parts and, accordingly, failure can be divided into two groups: permissible under normal operating conditions and inadmissible, which have emergency nature.

Possible damages include warping, some types of wear, fatigue of the surface layer.

Inadmissible breakage of parts as a result of insufficient strength, thermal cracks, in some cases - corrosion.

This division is rather arbitrary. If corrosion is a permissible damage to the ship's hull, then for the frame of the machine it is inadmissible damage. Failure of machines as a result of inadmissible bugs is eliminated as a result of emergency repairs.

Signs of damage

Each of the damages usually has its own characteristic features. The result of inadmissible damages in most cases is the destruction of parts in the form of stairs of the surface, fatigue failure, cracks. As a result of the influence of the working environment, there is corrosion and erosion of surfaces, burning, spraying, drying, fatigue, and much more.

2.2 Classification of failures

By cause of occurrence. Constructive failures are caused by mistakes made during design, violation of design rules. As a rule, this is the result of insufficient testing of dynamic loads, unsuccessful material selection and rigidity of power elements, improper planting and tolerance assignments, inconsistencies in calculated strength and wear resistance of the material, etc.

Constructive failures are repeatedly manifested in the process of exploitation it means they are systematic. This is due to the proliferation of design errors in the entire set of machines manufactured by this type.

The reasons for such failures with the corresponding reliability are established and eliminated.

Production (technological) failures arise due to a violation of the established process of manufacturing and repair of equipment. The most common reasons for the production failures are the non-compliance of the design documentation requirements to the manufacture, the use of materials with mechanical properties, different from the properties specified in the design documentation, the use of non-standard components, inadequate input and output control of elements and materials, etc. More detailed technological reasons are indicated in the appropriate classifier.

Industrial failures are also mostly systematic, if the violation of the technological process was spread in the production or repair of large batch machines.

Operating failures are the result of violations of the established rules and conditions of operation, as well as the natural wear of the conjugated parts, the accumulation of material tiredness, changes in material properties, mistakes of maintenance staff, etc.

By period of occurrence during operation. The change in the equipment failure rate in time characterizes three different periods of failure during the operation of the equipment before the write-off (Figure 1).

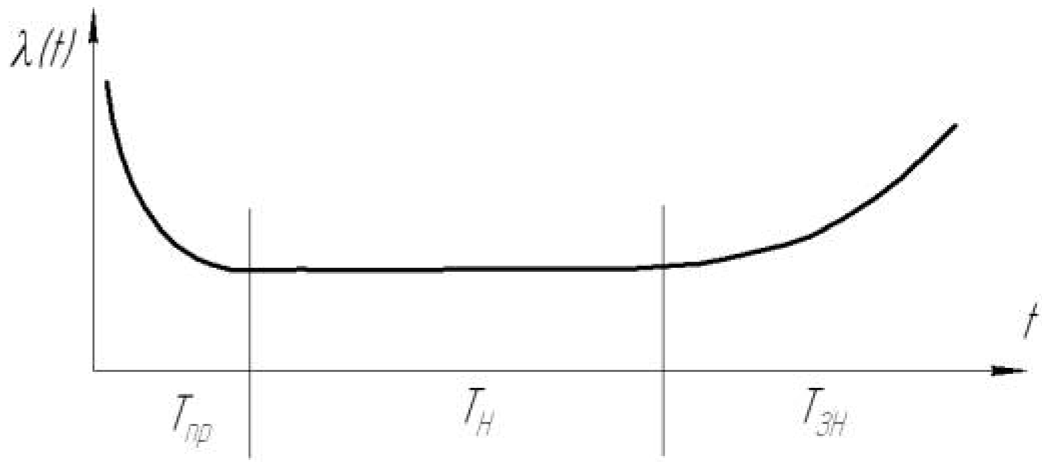

Figure 1 - Change in the intensity of equipment failures during operation before the write-off

The normal period of operation corresponds to the second plot in Fig. 1. duration $T_н$. For her, the bounce rate is stable. On this site, the process of working is finished. Aging, wear and tiredness of the material are not yet manifest, is the occurrence of failure is not due to the deterioration of the strength of the parts with the passage of time. These refusals are of an occasional nature and are a consequence of the unfavorable coincidence of many circumstances. This causes the intensity of the failure rate. The period of normal operation of $T_н$ is the longest.

Failure of aging (wear) and weariness corresponds to the third period $T_{зн}$ of operation of equipment, which is characterized by a sharp increase in the frequency of failures. The elimination of the failures of the third period is not economically feasible or physically impossible under exploitation conditions. This period is most operationally dangerous and is considered to be an emergency.

By nature of manifestation.

Gradual refusals - arise as a result of the course of a process of aging, wear, corrosion, fatigue, worsening the initial parameters of the product.

The main feature of a gradual refusal is that the probability of its occurrence $F(t)$ during a given time interval from t_1 to t_2 depends on the length of the previous work of the machine t_1. The time of the machine exploitation, the higher the probability of failure.

Sudden refusals - arise as a result of a coincidence of adverse external influences that exceed the ability of the machine to perceive it.

A refusal arises after a certain period of time $T_в$,, which is a random variable.

The distribution of failures on a given sign determines the speed of the change of the generalizing parameter U, which characterizes the capacity of the equipment (Fig. 2).

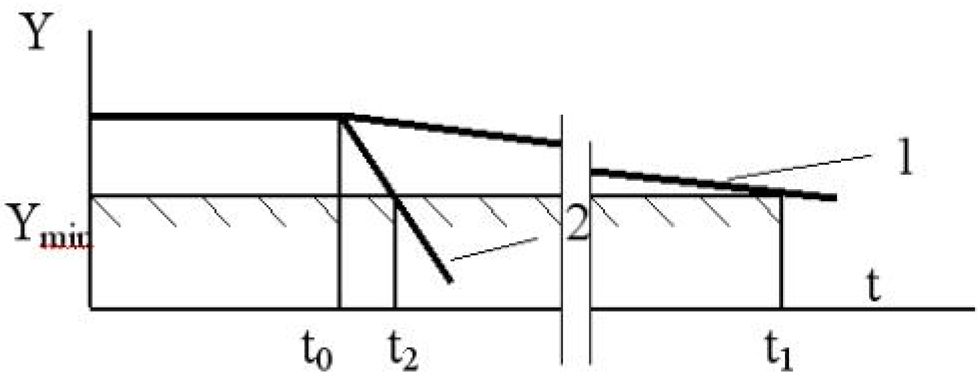

Figure 2 - Changing the generalization parameter, which characterizes the working capacity of the equipment

To gradual, include failures for which the rate of change of the generalizing parameter U has a finite value (curve 1).

The main feature of a gradual failure is the dependence of the moment of its occurrence t_1 on the duration of the previous operation of the element t_0. As the element is working time increases, the likelihood of a failure increases.

Gradual refusals are the result of irreversible changes in the time elapsed due to aging, wear, accumulation of damage, fatigue, temperature deformation, corrosion, and the like.

Sudden failures (curve 2 in Fig. 2) are characterized by a sharp, spin-like change in the generalizing parameter U under the influence of one or more perturbations caused by design, production, and operation errors.

The main symptom of sudden failures is the independence of the moment of failure t_2 from the duration of the previous operation of the element t_0.

Examples of such failures are failures due to the occurrence of cracks; parts breakdown due to improper operation or overload; breakage and deformation of the parts that got into the working conditions, when each parameter takes extreme value (the greatest load, the minimum strength of the material, the raised temperature, etc.).

Sudden failures are accidental, that is, they may occur at any time. It is completely impossible to remove sudden abandonment, but the reduction of the probability of their occurrence is practically realized.

On the possibility of forecasting. Gradual failures are predictable. The emergence of gradual failures always preceded by the appearance of direct or indirect signs of their approach: increased power consumption, reduced productivity, the appearance of noise and vibration, deterioration of the quality of products.

By interconnection Refusals are divided into dependent (refusal of one element induces a refusal of another or several) and independent if the two following, one after another, refusals are not related.

On a malfunction. The failures are divided into functional and parametric ones. Functional ones include failures in which the execution of functions by an object is impossible, to parametric ones - the failure of which some parameters of the object change in unacceptable limits. For example, the break of the chain of the corresponding transmission is a functional failure, and its elongation, which exceeds the permissible limits due to the wear of the hinges that connect the links, is a parametric failure.

Failure to operate - leads to the fact that the machine may not accurately perform its functions.

Parametric failure - leads to the output parameters (characteristics) of the machine beyond the permissible limits.

An example can be: reducing the accuracy of machining on the machine, reducing the engine's efficiency, and decreasing the performance of the automatic line.

2.3 Reasons for failure

The purpose of determining the causes of refusals at the stage of operation is the choice of actions to eliminate them. Objective analysis and proper systematization of the information received during the operation depend heavily on the completeness of the data on refusals and the conditions for their occurrence.

The complex of works to determine the reasons for refusals at enterprises is recommended to perform in sequence "consequence-cause", that is, by way of reverse occurrence, development and manifestation of the refusal: "the reason for refusal-state-the process of refusal-manifestation of failure."

It is advisable to use the following steps to analyze the reasons for the refusal.

Registration of refusal The failure factor is determined in accordance with the criteria for failure, which are given in the normative and technical and design documentation for a specific type of equipment.

Determination of the type (external manifestation) of the refusal. Same types (manifestations) of failure can be the result of failures of different nature. The main types that characterize the failures of machines include breakage, rupture, wear, cracks, corrosion and erosion, loss of rigidity of elastic elements, sediment deposition, cavitation, mixed failures.

For the analysis of failures in the enterprise conditions, disassembly, external inspection, check of conformity of sizes, gaps, mutual arrangement of the rejected part and adjacent to it, determination of mounting violations, etc.

Determination of the mechanism (process of destruction) of failure. A list of possible failure mechanisms is to monitor equipment in service. The approximate classifier of bounce mechanisms that results in tampering may be as follows.

Brittle cracking - destruction, which is accompanied by slight plastic deformation. The cracking plane is normal to the direction of maximum elongation of the semi-crystalline material.

Tired cracking - fracture under the influence of variable loads after applying a significant number of load cycles. Tired breakdowns are characterized by the presence of a fracture zone in the section with a low-grained surface and a zone of static (rapid) fracture of the residual section of the cross-section with a coarse-grained structure. There is also a classification of tired fractures, which allows you to determine the type and estimate the magnitude of workloads, the design features of the details that encourage the development of tired breakage. In the table-classifier of tired breakdowns, the conditions for the origin and development of cracks are clearly represented. This information can be used to determine the causes of failures and to develop measures to reduce hardware failures.

Viscous cracking - destruction, which is accompanied by significant plastic deformation. Distinguish the viscous fibrous and viscous shrinkage of the evil. Fibrous hacking is formed in conditions of flat deformed state, the hollow plane is perpendicular to the direction of maximum stretching stresses; viscous shrinking evil - under conditions of flat stress, the hole plane is inclined at an angle of 45 ° to the direction of maximum normal stresses (damage when tensing parts of the viscous materials with the neck).

The breakage of the torsion in the details of the viscous materials has a smooth, smooth structure. Thorns that occur when exceeding the strength limit, depending on the viscosity of the material and the shape of the shafts arise along the width, at a 45 ° angle or in combination. The surface of the breakage has a fibrous structure.

The damage caused by the bending load is characterized by tension on one side of the part and compression on the other. The starting point of tired fractures when bending found along the lines of unloading.

Determination of the reasons for refusals. All causes of failure can be divided into four groups.

1. Denials due to gross errors that arise in violation of design norms, with the disregard of requirements of the normative and technical documentation for designing in violation of the production technology and requirements of design and technological documentation, in violation of the rules and conditions of operation.

2. Failure due to hidden defects and damages, detection and prevention of which requires special studies of physical and chemical processes that arise in real conditions of operation (for example, changing the characteristics of the conjugated surfaces during the period of operation of the equipment depending on the load and temperature).

3. Failures that arise under the influence of external factors (dynamic loads, temperatures, vibrations, etc.), the values of which exceed the estimated.

4. Failures associated with natural aging and wear of materials and changes in the properties of lubricants during operation.

Also, the reasons for failures are classified into technological, operational and design. The approximate classifier of technological reasons for failures can be recommended the following:

defects due to violations of the composition of the material (the presence of inclusions, impurities, etc.);

defects in the molding and manufacturing of billets (presence of porosity, shrinkage shells, bundles, nonmetallic inclusions);

errors in machining (burns, tears, cracks, depressions, thermal damage to individual sites, etc.);

defects of heat treatment (hardening cracks, etc.);

defects in surface treatment (chemical diffusion, violation of the initial roughness of the surface);

build-up defects (surface damage, dirt, abrasives, mismatches in conjugated parts, etc.).

2.4 Wear of parts and units of machines

The service life of the equipment is determined mainly by the speed of wear of its parts and by the intensity of the loss of the mechanisms of the original functional and operational characteristics. Wear is called the process of destruction and separation of material from the surface of a solid, irreversible process of changing the shape, size and condition of the surfaces of parts of the machine during its operation. Depending on the working conditions, some parts wear out faster, others slower. The main types of wear are: mechanical and oxidative.

The first type of wear on the surface of the material of the parts, which together work, is the result of mechanical influences, resulting in abrasion and cutting contact surfaces. The intensity of mechanical wear significantly increases with the presence of friction abrasive dust, foreign solid particles, which leads to the formation of scratches on them. In addition, the size and nature of the wear of parts depends on the physical and mechanical properties of the upper layers of the material from which they are made, the value of the contact pressure, the relative speed of movement of the connecting surfaces, the conditions of their lubrication, roughness parameters, etc. In addition to wear due to the relative movement of contacting parts, it is possible to crunch their surface layers, which is characteristic for slotted, shovel, threaded and other joints.

During the work of machines, a number of their parts, including shafts, gears, rods, bearings, springs, etc., are exposed to variable loads, which leads to a much more intense reduction of their strength than under the influence of static loads. The effect of cyclic loads causes wear and tear and fracture of parts with the formation of cracks and fractures on their surfaces. The surface of the cracks zone is smooth, and the surface of the fracture zone is granular or with shells. This kind of worn surfaces suggests that the cause of the breakdown is fatigue. In order to prevent fracture from fatigue, it is necessary to correctly select the dimensions of the cross-section of the connecting part, the shape of which should be possible, without any sharp transitions from one site to another. It should also be taken into account that the presence of traces and scratches on the treated surface can also cause fatigue cracks.

Wear when zading occurs as a result of gripping one surface with the other, as well as deep excavation of the material. Such wear is the cause of insufficient lubrication and considerable specific pressure in the area of close contact between the two surfaces, resulting in intermolecular forces acting on them. Gripping occurs also at high slip speeds or in cases of exposure to large frictional surfaces, resulting in a significant increase in their temperature.

Oxidizing wear of parts surfaces occurs when they are directly exposed to water, air, chemicals and temperature fluctuations. Thus, unacceptable increase in the temperature of the air in the production room leads to the fact that the water vapor contained in it, comes in contact with the cooler metal parts and precipitates on them in the form of condensate. The latter causes corrosion of the metal, that is, it causes the beginning of the connection of the metal with oxygen and the destruction of parts with the loss of mechanical strength. The described phenomena are present at work of details of grinding, electrochemical and other machines, working in contact with water-emulsion cooling liquids. Due to the fact that the contact of a number of parts of one or another node of the machine is direct, corrosion wear is usually accompanied by mechanical impact. In this case, the so-called corrosion-mechanical wear occurs.

The presence of noticeable wear of certain parts of the equipment can be judged by the change in the nature of their work. For example, increased noise in gears is a sign of wearing the profile of their teeth. Inadmissible wear of slip and pin joints is manifested in the form of abrupt shocks when changing the direction of rotation or the linear movement of the actuating elements of the machine, driven by their use. By the level of noise, it is possible to estimate and the state of nodes with roller bearings. Diagnosis is performed using a special device - a stethoscope. In its absence, you can use a metal rod, applied rounded to the ear, and sharpened - to the point of the surface of the node, which is closest to the bearing. In the normal operation of the latter, only a faint noise, even a subtle buzz will be heard. Sharp, loud noises or whistles indicate that there is no lubrication in the bearing or the rolling bodies are too tightly clogged between the running tracks of the inner and outer rings. Intense noise, (frequent ringing, knocking) indicates that bullets, rollers or rings have formed shells or abrasive dust or dirt has fallen into the bearing. Deep strokes indicate a weakening of the bearing of the bearing in the housing or on the shaft.

The fact of substantial wear of assembly units of the machine can be installed not only by hearing, but also by the appearance of the workpiece surfaces treated on it. For example, the presence on the latter after the turning processing of evenly located circular protrusions or depressions indicates the wear of the teeth of the rail wheel and the rails of the mechanism of longitudinal feeding of the machine, as a result of which the movement of its support becomes more intermittent. This defect of treatment is often also caused by the wear of the surfaces of the guide racks and carriage, which leads to a violation of the coaxially of the apertures in the apron and the gear box for the installation of the running shaft; In addition, the gap in the track transfer is unacceptable.

An increase in the size of the "dead" movement of the arms of a longitudinal or transverse feeding of the support or the table of the machine tool indicates the wear of the threaded screws and nuts. In this case, under a dead pass, they understand a certain angle, when turning on which handles of the control of movement associated with it, the executive element of the machine does not occur.

It is recommended to use the method of "artificial bases" to estimate the value of wear of the friction surfaces of the basic parts of the equipment. In the implementation of the method on surfaces that are subject to wear, pre-squeezed wells of a certain shape (Figure 3).

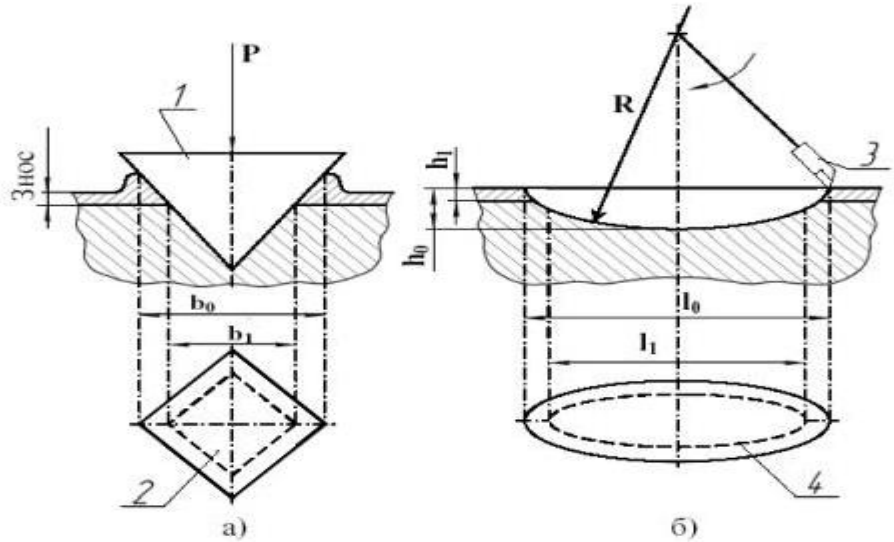

Figure 3 - Schemes of imprint (a) and holes (b) to determine the value of wear of guides: 1 - diamond pyramid; 2 - imprint; 3 - cutter; 4 – hole

In the change of the friction mode they practically do not affect, due to relatively small sizes: the depth of 50 - 75 microns, the length of 1.7 - 2 mm, the distance between adjacent wells 100 - 200 mm. The holes are executed using a diamond pyramid (the way of the prints), or using a rotating carbide roller (the method of "wiping"). The second method is more perfect, since when it is implemented on the sides of the hole, there is no raising of the metal, which allows for more accurate measurement. By the magnitude of the decrease in the depth of the well during a certain time of the machine, judge the value of wear. The depth of the hole is determined by the formula

$$h = \frac{L^2}{8r}.$$

where L is the length of the hole;

r - radius of curvature of the deepening.

3. MACHINE CLASSIFICATION BY MAIN OPERATING CHARACTERISTICS

3.1. Classification of machines

According to the main operational features, the machines are classified as follows:

- by way of work - mobile and stationary;
- by the form of an energy source (engine) - with a thermal engine (mechanical) and an electric motor (electric);
- by the number of executed operations - homogeneous, complex and universal;
- by the number of machines working in the unit - single and multi-machine.

Mobile is called such machines, which carry out technological operations during their movement. Stationary is the name of such machines that perform technological operations in one place. If, at intervals between the executions of operations, they can be moved from one polling station to another, they are called stationary and mobile.

All equipment of machine-building production for technological purposes is divided into four types: metal-cutting machine tools; forging and pressing equipment; woodworking equipment; foundry equipment.

The objects covered by the guidelines and norms of the Typical system for maintenance and repair of equipment are, first and foremost, different types of metal and woodworking equipment. Due to the complete constructive similarity of the corresponding models of metal and woodworking machine tools, manufactured and produced at domestic enterprises, enterprises of other countries of the former USSR, as well as foreign firms, the provisions of the Model system during their operation can be applied without any changes.

For equipment of other types, the provisions of the Model System can be disseminated only after a thorough analysis, and in some cases, after the necessary correction as a methodological guide for the organization of maintenance and repair, as well as the norms, structure and interconnection of the main provisions.

For each type of machine, its own parameters of the Model System (duration and structure of repair cycles, norms of labor and materials, etc.) are established, which correspond to the specifics of their operation.

Equipment of each type on a technological basis is divided into groups (for example, the main groups of the kind "metal-cutting machine tools" are turning, drilling, milling, grinding and other machines, forging and pressing equipment is divided into hammers, presses, scissors, etc.). Then in groups, according to the design, the cars are classified into types and standard sizes.

The above classification is necessarily taken into account when using the provisions of the Model System, since the equipment of each group and type is characterized by its repair features, which are determined, first of all, by its design. The composition of the groups that are divided into forging and pressing equipment and foundry equipment is given in the table of structures of repair cycles of the Model system, and the composition of groups and types all types equipment - in the tables with empirical formulas for determining the repair complexity, designed to take into account the design features of machines of each group and type.

The weight of equipment is one of the most important parameters from the size of which depends the complexity and material capacity of repair. Based on the mass value, machines of all types are divided into categories: light - up to 1 t; average - up to 10 tons; large - up to 30 tons; heavy - up to 100 tons; unique - more than 100 tons. In addition, equipment with a weight of up to 5 tons refers to transportable, and equipment weighing more than 5 tons - to non-transportable. The latter division is essential in determining the method of organizing its specialized repair. Thus, it is expedient to carry a transportable car to carry out repairs to a specialized repair factory, and specialized repair of non-transported equipment should be carried out with the assistance of outbound brigades.

By the degree of automation machines of all types are classified into varieties:

- equipment with manual control, at operation of which each individual (working or idle) movement is required, at least a team of workers is required;

- semi-automatic machines - machines that run the entire duty cycle in automatic mode and when using it from the installer or the operator only the initial setup, installation and fastening of the workpiece, removal of the processed part and the submission of the command to repeat the cycle are required;

- automatic is an equipment that performs all working operating cycles in automatic mode (including the setting and fixing of billets, as well as the removal of machined parts), and requires only debugging;

- software-controlled machines (CPCs,) are semiautomatic machines or automatic controlled by pre-fold and easy-to-replace programs.

Semi-automatic machines can be converted into automatic by means of various automation tools, special adapters, industrial robots (PRs) or software-controlled manipulators that provide automated installation and fixing of blanks, removal of machined parts, and filing commands for repeating the processing cycle.

Automatic machines are often combined into automatic lines.

An automated line is called a complex of machines, combined by a common transport system and electric, hydro, pneumatic systems.

Automatic lines are divided into single-line or hard-line lines (between equipment of such lines there are no intermediate storage devices) and multi-ducts or flexible lines, between machines with which drives are installed. The plot represents one machine or a set of several machines that are part of the automatic line and connected to other parts by means of drives.

Classification of equipment by the degree of automation is important in ensuring the rational organization of its maintenance and repair.

Thus, with an increase in the degree of automation of machines, labor costs for maintenance and repair increase, and the qualification of the implementation of the latter increases.

Depending on the accuracy parameters, all equipment is divided into five classes: normal accuracy (class H), big accuracy (class P), high accuracy (B), especially high precision (A) and extremely precise equipment (C).

Almost all forging, woodworking and foundry equipment belongs precisely to class H and its very small part to the class P. Most of the metal-cutting machine tools also have a class of accuracy N.

The machines of high precision are made on the basis of machines of normal accuracy of the corresponding standard sizes and differ from the latter mainly by more precise execution or more thorough selection of individual parts, as well as certain features of installation and operation of the consumer. They provide the accuracy of processing on average in the range of 0,6 deviations from the particle size of similar parts manufactured on machines of normal accuracy.

Machines of high and especially high accuracy from the corresponding models of machines of classes H and P differ in the design of individual elements and the highest precision of their manufacturing. Class B machines provide accuracy of processing within 0.4, and class A machines - within 0.25 deviations obtained on equipment of normal accuracy.

Especially precise machines of class C are intended for final processing of blanks of dividing and standard wheels and disks, measuring screws, etc. Acceptable deviations during processing on such equipment shall not exceed 0,16 deviations, which are regulated for the corresponding machines of class N.

Classification of machines in accuracy is necessary, firstly, to ensure the requirements for the accuracy of the production of replacement parts, as well as assembly for the repair of machine tools class B, A, S. Secondly, it is needed to correctly assess the complexity of their repair and repair complexity, performed operations maintenance and restoration of working capacity and serviceability.

Metal cutting machines are also classified into five subspecies, depending on the level of their specialization.

So, universal machines are called equipment, which serves to perform a wide range of machining operations in the manufacture of parts of a wide range of items (to this subspecies include turning, screw, radial, horizontal milling machines).

Wide-purpose machines are machines for carrying out a limited number of operations in the processing of billets of parts of a wide range of items (molded-cut, multi-turning lathes and semiautomatic devices).

Specialized machines are designed for manufacturing parts of the same name of different sizes (crankshafts, couplings, screws, etc.).

Special equipment is used to process billets of parts of a specific size.

Aggregate are called special purpose machines, which consist mainly of standardized, normalized and unified nodes and parts.

Classification of machines on this basis is important in terms of ensuring the correct planning of their repair and maintenance, as the level of specialization determines the structural complexity of the machine tools, and, consequently, the complexity of their repair and maintenance, which is taken into account in the empirical formulas for calculating repairs compliance. In addition, in connection with the classification under consideration, the general recommendation for the rational organization of automated production is the creation of it, primarily on the basis of special and aggregate machines, which provides less complexity of repair of automatic lines compared to lines based on universal equipment.

3.2. Periods of machines operation

Under the operation of the machine understand the entire period of its existence from the factory to the decommissioning, which consists of separate periods (Table 3.1).

For certain machines, depending on their purpose, certain combinations of the listed periods and their duration.

For example, for technological equipment, conservation and transportation are characteristic only in the initial period of operation. The main ones during operation will be periods of operation and periodic devices in repair, as well as simple when incomplete use of the machine. On the contrary, military equipment is characterized by long periods of storage and periodic inspections and a short period of use.

The structure of the operation process and the duration of individual periods depends largely on the choice of reliability indicators, which reflect the requirements of both the reliability of the product during its operation and the possibility of long-term maintenance of the product's performance. Classification of machines in a cyclical way is shown in Table. 1.1.

Table 1.1 - Periods of machines operation

Operation period	Workability
1	2
1. Machine downtime: - preservation and storage; - transportation; - check of workability (diagnostics) or preparation for work (adjusting); - downtime (waiting) of work or repair.	As a rule it changes slightly
2. Machine operation: - work under normal conditions; - work at high modes; - work under reduced modes; - work at inspections and tests.	Decreases
3. Machine repair: - scheduled periodic works; - maintenance; emergency repairs.	Is restored

Table 1.2 - Classification of machines according to the cyclicality of their work

Group	The nature of the machine work in time	During work are possible	Period of failures evaluation	Examples of machines

1	2	3	4	5	6
1	Continuous work for all time of operation	-	+	The whole period of operation	Hydraulic turbines, controlled spacecraft
2	Periodic or continuous work with allowable stops	+	+	Inter-repair period	Technological machines (machines, textile, printing, household)
3	Season work	-	+	Season duration	Agricultural machinery, processing industry
4	Work periods, portions	-	+	Required work duration	Transportation vehicles
5	Short-term work	-	-	Period of storage, work	Military equipment, missiles

3.3 Reliability of the «man-machine» system

When exploiting complex machines and complexes, the person and the machine becomeunited into a single system. The efficiency and reliability of this system depends to a large extent on the qualities of the operator, as well as on the suitability of the machine to interact with the person.

Qualitative indicators of a person are characterized, first of all, by his qualification, that is, the ability to control the machine and professional responsibility.

The design of the car, in turn, must take into account the physiological and psychological capabilities of the person. These tasks are solved by science of ergonomics. It examines the functional capabilities and features of the person involved in the production processes, and promotes the creation of such conditions of methods and organization of work, which make it highly productive and at the same time create convenience and safety in the work. The human factor in modern production is one of the most important, on which depends the efficiency and reliability of the use of technology. As the analysis of accidents, violations of technological processes, errors of control in complex technological systems, they arise as a result of the fact that the design of machines and devices does not sufficiently take into account the features and abilities of man.

Ergonomic properties of a person represent a complex of anthropometric, physiological and psychological properties, which are regulated by the relevant standards. Thus, anthropometric properties of a person determine the typical dimensions and shape of the human body and its individual parts, which, in turn, determine the size of the machine, the placement of individual parts and mechanisms, primarily controls.

The machine must take into account such physiological properties of a person as the ability to perceive or create appropriate loads, fatigue, the presence of appropriate biorhythms, the speed of action, the ability to perceive accelerations, etc.

Significant influence, especially in the creation of control systems, have psychophysiological properties of a person associated with sensory organs: sight, hearing, and touch.

If necessary, the operator's rapid response to certain signals must take into account that it is within the following limits: visual signal - 150 ... 225 ms; auditory - 120 ... 182 ms; temperature - 150 ... 240 ms; and pain - 400 ... 1000 ms. From these data it follows that through the rumor the signal is perceived the fastest, therefore, in some cases, it is possible to unload the operator from the visual signals due to the sound.

The design of the machine must protect the person from unacceptable effects on her nervous system - excessive noise, too bright or insufficient light, too much signal of information. Management bodies should not also cause physical fatigue of the person at the expense of the efforts necessary to move the management bodies to the inconvenience of their location.

All of these factors affect the reliability of the system man - machine, especially in emergencies. It is necessary to remember about the dual role of a person from the standpoint of reliability: on the one hand, a person is a very perfect system that can assess the situation and make such decisions, which no control machine can, on the other hand, a person can make false positives, if her nervous system and physical condition are inaccessible.

3.4 Specter of operational loads

Reliability indicators depend on the conditions in which the machines are operated and from the modes of its operation.

Scattering of loads, velocities, temperatures, humidity, dust and other parameters of the environment in which the machine operates is the main cause of the random nature of the process of changing its initial parameters.

The environment significantly affects the work of those machines that work outside the premises and have direct contact with the environment (pressure, temperature, wind, recession, dust). Machines, the operation of which takes place in stationary factory conditions, also perceive various loads, have an unstable cycle of work, are subjected to the influence of neighboring machines and aggregates.

The spectra of operational loads for a variety of machines, and their elements are presented in the form of probability density curves for the corresponding factor. For example, a study of power distribution on a spindle of lathe machines shows a significant unevenness in loading machines and the small use of maximum permissible loads. These dependencies can in many cases be described by the laws of Rayleigh, logarithmically normal, or other asymmetric distribution law. In some cases, a normal law is used.

3.5 Collection and processing of operational information

Information about typical failures, on the terms of service of parts and units and the complexity of their repairs, obtained as a result of the collection and processing of a large number of observations during the operation of machines, provide reliable information about their actual performance. This information can be used effectively for the modernization of machines, as well as for the development of a rational system of repair and maintenance.

In engineering, a system of standards has been developed that regulates the procedure for collecting and recording information on the reliability of products, and the methods for statistical processing of information. There is a generalized list of all kinds of machine failures and evaluation of their reliability indicators for all branches of machine building. On the basis of state standards, industry-specific sectoral developments are being developed.

When using products, special attention is paid to failures that are associated with severe consequences: a danger to human life, or significant economic costs. Reasons for product failure before the established resource

In the course of operation of the machine, refusals often occur before the resource is set. Some causes are caused by them (Table1.3).

Table 1.3 - Causes and perpetrators of premature failure

Causes of premature failure	Culprit
Incorrect calculation of product reliability Incorrect appointment of technical instructions on product parameters	Designer
Violation of technical instructions during the manufacture and testing of the product	Technologist
Violation of modes and conditions of operation	Operator

Strategy of technical exploitation. The ultimate goal of the production process is to obtain the maximum amount of products at a minimum cost of material and technical resources.

For the park of machinery of the machine-building enterprise, the task is to execute the maximum amount of work in the prescribed time period, with the given performance and quality, at minimum expenses.

To solve this problem, it is necessary to correctly select the composition of the fleet of machine, to seek their maximum load, which will reduce the cost of depreciation, storage and maintenance, which fall on the unit of work performed.

In addition, it is necessary to apply a rational system of maintenance and repair, which would take into account the specifics and designation of machines.

4. STRUCTURE AND PERIODICITY OF PLANNED MAINTENANCE AND REPAIR OF EQUIPMENT

4.1 Repair cycle of equipment

Efficiency and technological returns of equipment are determined not only by its technical characteristics, but also by a lot of rational operation, which involves planned periodic stops for maintenance and repair.

All work on planned maintenance and repair of machines is performed in a certain sequence and form repetitive cycles.

Equipment repair cycle (ERC) is a recurring set of different types of scheduled repairs performed in the foreseeable sequence due to the establishment of an equal number of hours of operating time of the equipment, called the inter-repair period. The repair cycle is completed by major repairs and characterized by structure and durability.

The structure of the repair cycle (SRC) is a list of repairs that are part of the repair cycle, placed in a sequence of their execution.

For example: a structure consisting of one capital, one medium and four current repairs, is written as follows:

CP-CR-CR-MR-CR-CR-MR

The duration of the repair cycle (DRC) is the number of hours of operating time of the equipment during which all repairs that are part of the cycle are carried out.

Simple equipment related to the implementation of planned and unplanned repairs, as well as maintenance in the duration of the repair cycle are not included.

The duration of the repair cycle represents the dimensional line between the designations of capital repairs, which begin and end the cycle. Over the dimensional line indicate the duration of the cycle in hours, for example:

CP-CR-CR-MR-CR-CR-MR=2000 hours

Empirical formulas for the duration of repair cycles are a product of a constant for each type of equipment of the factor of coefficients that have variables:

For metal cutting equipment:

$$T_{цр} = 16800\, к_{ом}\, к_{мі}\, к_{то}\, к_{км}\, к_{в}\, к_{д},$$ hours

For press-forging equipment:

$$T_{цр} = 10000\, к_{ро}\, к_{в}\, к_{д},$$ hours

For foundry equipment:

$$T_{цр} = 6000\, к_{ро}\, к_{в}\, к_{д},$$ hours

Where:

K_{om} - coefficient of processed material;

K_{mi} - instrument rate that are used;

K_{mo} - coefficient of accuracy class of equipment;

K_{km} - weight category;

$K_{в}$ - age factor;

K_{d} - durability factor;

K_{po} - coefficient of repair features.

Inter-repair period (T_{mp}) is a period of operative time of operation of equipment between two consecutive planned repairs. The duration of the repair period is equal to the duration of the repair cycle, divided by the number of intra-cycle repairs plus 1:

$$T_{мр} = \frac{T_{цр}}{n_{с} + n_{п} + 1},$$

Where n_{c} - number of average repairs;

n_{n} - number of current repairs.

The duration of the repair cycle is determined by the class of accuracy of the machine, the conditions of its operation (air dust, category of material of the working part of the tool (metal or abrasive), the hardness of the treated material, etc.), the machining modes used, the type of production, and, finally, the service life of those main mechanisms and parts equipment whose replacement or repair can be carried out during its complete disassembly. The average duration of the repair cycle for light and medium metal cutting machines is about 30,000 working hours (with a two-shift operation period of 90 months), inter-repair period - 10 months, interim inspection period - 5 months.

4.2 Maintenance cycle

Maintenance cycle (MC) is a recurring set of operations of different types of scheduled maintenance performed through the number of hours of operational time set for each equipment, called the interoperable servicing periods (ISP). The maintenance cycle is determined by the structure and duration.

Structure of the maintenance cycle is a list of scheduled maintenance operations that are part of a cycle with coefficients that indicate the number of operations of each type in a cycle.

The structure of the maintenance cycle is shown in the form of the amount of operations included in the cycle. To indicate the number of operations performed on a daily basis, the letter "D" is used as a factor. Maintenance operations performed by non-repair personnel (machine tool operators, cleaners) are not included in the structure of the maintenance cycle.

The duration of the cycle of maintenance and the duration of the inter-repair period are equal among themselves, because all scheduled maintenance operations are performed between two consecutive planned repairs.

Interoperable maintenance period is the period of operative time of operation of the equipment between two successive executed one-named scheduled maintenance operations.

Different types of equipment and different operating conditions of the same type of equipment provide different structure and length of repair cycles, as well as the number of planned inspections in maintenance cycles.

Manufacturers of equipment must ensure the durability of basic equipment parts, equal to the duration of the repair cycle.

If it is technically impossible or economically inexpedient to provide this longevity for parts other than those that are rapidly wearing, then it should be equal to half the length of the repair cycle, so that the replacement of these parts is carried out, with the average repair of the three-period structure, with the third ongoing repair of the six-period or the fourth repair eight-period structure, that is, in the middle of the repair cycle.

4.3 Maintenance of equipment

In order to ensure the long-term maintenance of equipment, reducing the amount of maintenance and restoration expenses, as well as minimizing the losses of the main production, connected with downtime of machines caused by their malfunctions, it is necessary to rationalize the organization of operation, maintenance and repair of equipment.

In the activity of enterprises maintenance of machinery must be in the first place, and repair, which should not be considered as an end in itself - on the second.

To ensure the most rational organization of maintenance of equipment, there is a need for clear regulation and planning of the possibility of all its operations in terms of content and frequency of execution, as well as the proper allocation of operations between different performers.

However, it is practically impossible to regulate all the work related to maintenance of machines, since it requires continuous monitoring of the occurrence and development of failures of a random nature, in the state of all wearable parts and the violation of all irresponsible moving and fixed demountable connections.

Keeping equipment operational and reducing the cost of maintaining it requires rational organization of operation and obligatory performance of works related to its maintenance.

The rational organization of maintenance requires clear regulation and planning of all types of work, but this is practically impossible, as this requires constant supervision of the occurrence of occasional failures. Therefore, in addition to the regulated work of maintenance requires, unplanned works are carried out, if necessary.

4.4. Planned maintenance of equipment

A planned inspection is an operation performed to check all nodes, accumulation of information about the degree of wear of parts and connections necessary for preparation for repairs. Performed according to a certain scheme, because of the standard set by the typical system, the number of hours of operational time worked out by equipment, without disassembling nodes visually, or with the help of technical diagnostic tools.

During and after inspection, it is possible to eliminate such minor faults, the presence of which does not allow the normal operation of the equipment to the nearest planned repair (scrubbing, scratching, cracking, etc.). Planned inspections are carried out by the repair service workers, usually during non-working hours. In this case, machines operating in conditions of severe pollution, partially dismantled and washed; precision equipment is checked for accuracy. In the operation of automatic lines and heavy machines, the need for preventive inspections is greater than with the use of equipment with manual control and light machines, in connection with which, their number in the structure of the repair cycle is doubled, which prevents the premature failure of machines.

Shift overview is a planned maintenance operation performed to:

- Identify and evaluate changes in the state of the individual least reliable items of equipment and prevent their failure at work;

- Supervision over the implementation of the rules of operation and safety, prevention of their violations.

Changing overview - every work shift is carried out without stopping the equipment operation, according to its results, work is done on the elimination of deficiencies.

Periodic partial inspection - is carried out for the same purpose as shift overview, but for a wider range of parts and connections, in the amount set by the map of scheduled maintenance (PTO) without stopping the equipment.

Carrying out this operation is necessary only for a part of the least reliable models of cars. According to the results of the review, minor faults can be eliminated.

Shift changes in the maintenance of equipment cleanliness is an operation performed to prevent the premature destruction of the working surfaces of equipment, the protection of workers from possible injury, the maintenance of the requirements of industrial aesthetics. Performed by the machine tool at the end of the working shift, and if necessary several times per shift.

Shift changeable lubrication is an operation performed to prevent the premature wear of the rubble surfaces.

Renewal or change of lubricants in tanks of reducers or cases due to evaporation, leakage or deterioration of their properties as a result of operation. Performed according to the lacing card due to the set number of hours of work.

The washing of the mechanisms and systems of lubrication is carried out in order to prevent the accelerated wear of parts and knots in connection with the contamination of systems by abrasive particles of dust, products of treatment and wear. Performed through the number of hours set by the VT card and can be combined with the replacement of lubricants.

Periodic cleaning of electric dust and electronic parts of equipment, which is performed for the purpose of:

- prevention of system failures due to the closure of dust bridges;
- prevention of injuries due to possible mechanical damage to the insulation and ground, hidden under a dust layer;
- maintaining the requirements of industrial aesthetics.

Performed by electricians and repairmen through the set number of hours spent by the equipment.

Adjustment of mechanisms, devices, elements, replacement of wearing parts and pulling up of cutting joints is carried out with the aim of:

- preservation or restoration of passport productivity of equipment, accuracy of processing and safety of operation;
- prevention of progressive wear and prevention of breakage of parts.

The operation can be planned and unplanned, as a result of the review.

Verification of geometric and technological precision - is performed to prevent the occurrence of defects in the manufacture of parts. Performed according to manufacturer's recommendations.

Inactive machines, which, due to changes in the composition, volume or production technology of manufactured products, will not be exploited in the planned year, but not dismantled, taking into account possible future use, also require maintenance.

4.4 Map of planned maintenance

A plan maintenance plan is a document provided by the manufacturer as part of the accompanying technical documentation with each unit of equipment, which contains:

a) a list of all types of work that must be performed during scheduled maintenance, their content and a brief description;

b) number of operations - in the maintenance cycle;

c) the maximum permissible inter-operative maintenance period for operations;

г) complexity of execution of each operation;

e) the composition of each operation.

The map of the planned maintenance can be developed on each model of equipment or on a group of constructively close models.

5. PROCEDURE FOR INSTALLING MACHINES FOR OPERATION

5.1. Arrangement of premises for storage and use of machines

Prolonged preservation of metal-cutting machine tools and forge-press equipment of initial technical parameters is possible only when installed in closed heating areas, which provide:

- protection against atmospheric precipitation;
- protection from external sources of air polluting and aggressive gases (only traces of gaseous acids and alkalis are allowed);
- maintaining the permissible air temperature within the interval depending on the given accuracy of processing;
- maintaining the permissible air humidity within the interval depending on the actual temperature.

Machines of precision grades H and P can be installed in the common premises of the enterprise. In this case, if abrasive or metal dust is extensively used during the operation of the machine (an abrasive tool is used or a cast iron is used), it must necessarily be equipped with exhaust devices to protect the air against pollution.

However, machines that operate an abrasive tool, it is desirable to install separately from the machine tools, in which the tool is used metal. To keep the air clean, the premises are equipped with forced ventilation with a dust filter.

Equipment Classes B, A and C should only be installed in isolated rooms. In this case it is unacceptable to jointly establish different types of machine tools of these classes, even those that are close to the technological purpose or the material of the tool (for example, tooth and thread-grinding).

The systems of inflow ventilation in premises where the machines of classes B, A and C are installed must be equipped with devices for heating the air.

The normal temperature of the air in the production premises of machine-building enterprises is + 20 ° C. Depending on the accuracy class of the installed equipment, the following deviations from the nominal temperature are allowed (Table 1.4)

Table 1.4 Permissible fluctuations of temperature in the production premises, depending on the accuracy class of machine tools

Class of machine accuracy	Н	П	В	А	С
Permissible fluctuations of temperature □C	□10	□5	□2	□1	□0,5

Accordingly, allowable fluctuations of humidity in the room with the equipment, based on the actual temperature of air in it are: 40 - 75% at a temperature below 24 ° C; 40-60% at a temperature below 28 ° C; 40 - 55% at a temperature higher than 28 ° C.

In the winter, the permissible temperature interval in rooms with cars of classes H and P can be provided with the help of centralized heating systems of any type, in the summertime - with the use of inflow and exhaust ventilation.

The best type of heating system for premises with class B, A and C equipment is air heating. It is also possible to use water heating, the radiators of which should be located not closer than 1 m from the machines and must be closed with heat-insulating screens.

In rooms for class B equipment, the temperature can be adjusted using the heating system valves. Workshops with class A and C machines should be equipped with automatic air conditioners.

The general lighting of the premises should be provided with hanging daylight fixtures and in combination with the local lighting from the network with a voltage not higher than 36 V must comply with the rules and regulations of artificial lighting of industrial enterprises.

The dimensions and layout of the premises should allow free access to all components of the equipment mounted on them during its operation. In addition, it is necessary to provide space for cabinets, stands, shelves, trays and storage tanks for workpieces, machined parts, tools, accessories, controls, equipment for inventory, cleaning materials, lubricants. Unoccupied areas around machines should be sufficient to ensure that they can be disassembled at the nodes during repairs, as well as for transportation from the premises in a collection to be sent to a specialized repair facility of any unit of equipment up to 10 tons. For this purpose, in premises intended for the installation of four or more machines, a free passage width of not less than the width of the largest in the dimensions of the transportable machine plus 0.5 m should be provided.

The exit from the premises is recommended to arrange through a tambour with a dual enclosed gate, a width sufficient for passing through them the largest of the machines installed in the shop and with separate doors for the passage of people, equipped with devices for self-closing. In addition, the obligatory for the vestibule is a heat curtain. Exit from the premises for precision equipment is desirable to arrange inside the workshop, and in its vestibule to bring the nozzle of tidal ventilation to create an excess pressure of 10 - 20 Pa.

Flooring in shops is recommended to be covered with plastics (phenolite-4, phenolite-5) or linoleum on a concrete basis. It is also possible to use tiles of stone casting or metal tiles, but in the latter case, around the machines, it is also necessary to enclose rubber tracks with a width of not less than 700 mm. Xylolithic floor coverings are forbidden to avoid corrosion of metal parts of equipment under the influence of xylolytic acid.

Window openings in the premises in which the machines are assembled must be closed with double-blind openings. In shops with precision equipment it is allowed to arrange windows only from the north-west, north and north-eastern side. In this case, the windows on the north-eastern side must be equipped with louvre lattices or curtains made of a dense material that does not allow to enter the surface of machines of direct sunlight.

The rooms for the installation of machines must be equipped with lifting and transport mechanisms with an electric drive, in an amount in which the uninterrupted operation of all main equipment is ensured. The lifting capacity of these mechanisms should correspond to the largest mass of workpiece allowed to be processed on the equipment for which they are intended to be serviced. It is also desirable that the workshop also has a bridge mounted crane for disassembling the machines at the sites during repairs that are carried out at the site of operation. It is not recommended to use pneumatic lifters to service coordinate boring machines.

In the premises for the installation of CNC machines need to lay a low-voltage grounding bus, to which to connect the wires grounding cabinets. In this case, the electrical resistance of the grounding circuit should not exceed 4 ohms.

In casting equipment shops, it is necessary to mount reinforced suction and exhaust ventilation to remove dust and gas from the working zones and to supply fresh air to them. Additionally, there is a special piping with silencers for removing from working areas of compressed air and avoiding the associated lowering of temperature, increasing noise and dusting the working areas.

For those machines for which the documentation provides initial period it should be carried out in accordance with the procedure given in the instruction. Since in the initial period there is a mutual tuning of parts and joints, and accordingly their intense wear during the run, the machine is not allowed to load at full capacity, because it can lead to its failure. Properly performed rigging largely determines the durability of the machine. The equipment runs out after approximately 200 hours of operation.

5.2 Installing and fixing equipment

In order to obtain the parts with the given dimensions and roughness of the treated surfaces, it is necessary to protect the metal-cutting machines on which they are manufactured from external vibration disturbances caused by the work with shock loads of equipment located near them, machines with unbalanced moving masses, the actuating elements of which carry out reciprocating transportation, as well as all modes of transport. The same applies to blacksmithing equipment.

However, it should be noted that even the installation of machines in isolated premises does not fully protect them against vibrations that are transmitted through the soil. In addition, partial extinction of vibrations can be achieved by mounting equipment on separate foundations or on special vibro-assemblies.

In the documentation given by the manufacturing plants together with the machines, there are usually instructions on how to arrange their foundations and to ensure effective vibration isolation.

Thus, a number of manufacturers recommends, for the quenching of vibrations transmitted through the soil, to surround the concrete foundations of machines with a layer of crushed crushed stone, peat, slag or slag in the thickness of 50-100 mm.

In some cases, an effective vibration isolation of the equipment can be provided without the foundation arrangement when mounted on a general concrete panel of the shop, based on elastic supports or gaskets. In this case, the floor of the shop should be sufficiently smooth to better fit the gaskets and increase the uniformity of their load, and, consequently, durability.

When choosing the type of foundation for the installation of any machine, regardless of its purpose, the following key factors, such as the class of equipment precision, the nature of the workload, the stiffness of the structure and the mass, must be taken into account.

The best, though at the same time, and the most expensive type of base for mounting Class C machines, should be considered massive concrete foundations mounted on springs with damps to mitigate fluctuations caused by accidental causes.

Class A equipment should also be mounted on individual concrete foundations that are surrounded by a vibration insulating layer or an air gap of at least 100 mm in width. Similarly, lightweight and medium-class machines of Class B are installed with non-rigid beds that are supported by more than three points, as well as large and heavy machines of similar accuracy, regardless of the rigidity of their beds.

Machine tools of Classes B, P and H of light and medium category with rigid three support posts, which do not have sharply reversed knots, can be mounted on vibro pillars or rubber pads on the general concrete panel of the shop.

Class-II machines with non-rigid mounts, large and heavy equipment of the same class - regardless of the rigidity of its mounts, can be installed directly on the concrete floor without the use of rubber pads.

When arranging the foundation on a normal cement or slag-portland cement, the machine can be installed on it not earlier than seven days after completion of concrete laying, while the start of equipment is allowed only on the twenty-second day. If necessary, the acceleration of the introduction of the machine into operation after the completion of its mounting, use of rapidly cemented cement.

To protect the foundation from the destruction of oils it is recommended to iron its top surface cement mortar in a mixture with liquid glass.

The guidelines for arranging the foundations of forging and pressing machines and foundry machines are sent by the factories, together with the equipment. Typically, these foundations are massive concrete blocks or slabs, isolated from the ground by a layer of sand, gravel or ash, enclosed by free molding without strain. In this case, the thickness of the filling layer depends on the load capacity of the mounted equipment. For example, when carrying a molding machine up to 1200 kg, the thickness of the layer is taken equal to 0.3 m, with a higher power of the machine - 0.3 - 0.8 m.

Transport of the equipment of classes B, A and C, as well as CNC machines, regardless of their accuracy class, can be carried on sheet metal using winches and gaskets, but only with sufficient straightness and cleanliness of the floor, because otherwise the probable loss of equipment accuracy as a result of shaking and pushing in the process of moving.

If it is necessary to lift the machine, special attention should be paid to its correct balancing. Boxes with equipment packed in them may not be lifted by the covers. Of course, the box is suspended on ropes that are rolled into the special grooves of its bottom. It is also necessary that the angle between the ropes during lifting does not exceed 45 °.

Unpacking the machine requires strict conformity with the instructions of the manufacturer. Small, lightweight equipment can be unpacked manually, whereas when removing large, medium and heavy vehicles from containers, in most cases a bridge crane is used. When lifting the lid of the drawer with the side walls, make sure that the protruding parts of the equipment are not damaged.

It is not allowed to lift unpacked machines with the help of sling chains. Cable ropes should not allow the possibility of damage to the staining of equipment surfaces or the deformation of its protruding parts (handles, handwheels, etc.). For this purpose, it is necessary to insert protective fabric rollers between the cables and surfaces of the machine. In this case, the angle between the cables should not be greater than 30 °.

Heavy and unique equipment is often supplied in a disassembled unit, due to which, in order to avoid damage during transportation, between the surfaces of its guides are usually installed plastic pads, removal of which during the installation of the machine requires a great deal of diligence and appropriate qualifications of the workers (in otherwise, damage to these surfaces may be possible).

Most of the precision machine tools are mounted on a pre-prepared foundation without attachment of anchor bolts or pouring the base with cement mortar. Typically, the installation of such equipment is carried out on three or more of the number of supports of a double type, with the help of which the position of the base of the machine can be verified with an accuracy of 0.01 / 1000 mm.

Machines, the nodes of which during the work carry out reciprocating displacements, fasten to the foundation anchor bolts; the base is filled with cement mortar. The start of such equipment is allowed not earlier than 72 hours after completion of pouring the solution to ensure its complete solidification and seizing.

During the mounting of the machine nodes, they are gradually released from the protective anticorrosive coating (lubricant or special opaque paper). Remove the protective layer of the brush using pure gasoline or kerosene and with technical napkins. After thorough cleaning and washing of parts, a thin layer of grease is applied on their surfaces.

The equipment arriving in a folded form from the anticorrosion coating is released after the completion of the mounting of its mechanical and electrical parts. It is strictly forbidden to move moving parts of the car before removing the cover.

The sequence of mounting individual nodes, mechanisms and devices of different models of machines may differ, in connection with which it should be carried out strictly in accordance with the factory instructions.

When connecting equipment to the mains, it is necessary to check the direction of rotation of the shafts of its electric motors, which is often allowed only in one direction.

The installation of CNC machines is quite complicated and can be started only if there is an appropriate qualification in the enterprise-consumer, or after concluding an agreement with the manufacturer-manufacturer on the provision of monterial assistance.

The CNC equipment is connected to a four-wire AC network with a voltage of 380/220 V%, with a frequency of 50 ± 1 Hz. To protect against electrical interference caused by the operation of other electrical equipment, it is recommended to supply the PFCP from a separate motor-generator or power transformer. In this case, connecting to this motor-generator or power transformer other machines are not allowed.

When performing rigging, mounting the mechanical part, and especially when mounting the electrical part of the equipment, the greatest attention should be paid to compliance with safety requirements. The machine cannot be put into operation without grounding its bed. Upon completion of the installation of equipment in the shop and before the test, it is necessary to withstand it at the permissible operating temperature: in summer and in dry time - not less than a day, and in winter or in wet weather - not less than three days for complete drying of isolation of windings of electric motors and wiring.

After the mounting, the car is exposed to the outside. Make sure all its cartridges, tanks and individual lubrication points are clean, and then fill them with grease according to the diagram and grease card.

5.3 Testing and receiving equipment

After inspection, metal cutting and woodworking machines are tested at idling speed, under load and in operation, and then checked for accuracy.

Tests at idle start with handwheel turns of the feeder and spindles of the machine. After the first start of the machine, the lubricant is poured into the reservoirs of the centralized lubrication system, discharged through the hydrolysis, its level will decrease, so the lubricant must be poured.

At idle and under load, the machine must be tested consistently at all rotational speeds and feeds; it is necessary to check the performance of all kinematic chains. If this is not detected signs indicating malfunction machine (knock in the mechanisms, vibration, rocking, unauthorized switching speeds and feeds, overheating bearings etc.), the machine can be proven to work, and then checked for accuracy according to the methods and standards of the relevant standard. The duration of the test at idling should be not less than two hours, and at work - not less than 30 minutes.

In the CNC after checking idling in debug mode, all kinematic chains plug control unit and check its performance in the elaboration of the program given treatment regimen. In this case, malfunctions due to defects in the PFPC or in the drives of the machine may be detected, which must be attempted to be eliminated by adjusting the equipment, in accordance with the operating documentation. At normal operation of the machine at idling start its tests under load. Tests in the software control mode are carried out according to the recommendations and instructions of the machine-tool manufacturing plants and the FVC.

Press-forging and casting equipment before putting it into operation should be subjected to break-: idling - 7 - 8 hours, and under load that does not exceed 50% of the nominal effort - within the time specified in the instruction manual, but at least 50 - 60 years

If the obtained test results are positive, broadcast equipment into operation for the act prepared by the appropriate form [1], the mandatory presence of department chief engineer, department chief engineer, technical control department and department in which it is mounted. The machine must be specified in the certificate according to the passport data, confirmed by the test results.

Upon receipt of poor test results, as well as in the cases where the precision equipment is lower passport, you should call the manufacturer's representative for laying reclamation act.

During the first month after putting the car into operation should not be subjected to its maximum load, it is necessary to work in medium modes.

Approximately after 200 hours of operation, after putting into operation of the equipment, it is necessary to stop and inspect, rinse and refill fresh tanks with all the tanks, cartridges and individual lubrication points.

From this moment the car is transferred to normal operation. For it to be folded schedule of reviews, checks the accuracy, washes and repairs performed at a certain optimum frequency for the installed machines of this type, except for supervision of foundation, which is only for the first seven months of work.

5.4. Procedure for conducting entrance examinations

Requirements for metal-cutting machine tools are determined by the need to obtain the specified accuracy and cleanliness of the surface of the machined parts and the given performance.

Accordingly, the testing (production) tests of the machine include:

a) checking the quality of its production (processing of parts and assembly);

b) verification of electro-, hydro- and pneumatic equipment of the machine, its systems of lubrication and cooling;

c) testing of the machine at idle with the verification of the operation of all mechanisms and passport data;

d) test of the machine in work under load and on productivity;

e) Checking the machine for geometric precision, surface cleanliness and precision of the workpiece.

In addition, laboratory tests of machine tools for rigidity, power, vibration resistance, and determination of k.k.d. drive machine

The check on the purity of the treatment and the accuracy of the processed product is allowed when testing the item "g" to check for geometric accuracy.

Acceptance tests are carried out during the acceptance of a new or repaired machine.

5.5 Testing machines at idling speed

Testing of the machine at idling speed is carried out by successive inclusion of all its working speeds from the smallest to the largest, and at the highest speed - until the constant temperature in the bearings, but not less than half an hour. The temperature of the spindle bearings should not exceed 70 ° for bearings and 85 ° for roller bearings. In other mechanisms (feed boxes, etc.), the temperature of the bearings in similar tests should not exceed 50 °.

The feeder mechanism is tested at idle speed for the smallest, medium and largest working feeds, as well as at the speed (accelerated) feed, if it is at the machine.

When testing a machine at idle, check:

a) all the inclusion, switching and transmission of control bodies to the correctness of their operation, mutual locking, reliable fixation and the absence of involuntary displacements, seals and scrolling; permissible lateral displacement (non-matching) of the conjugated gear wheels, with their fixed position for wheels with a width of the crown to 30 mm, should not exceed 5% of the width of the crown, and for wheels more than 30 mm - 3%;

b) the efforts on the organs of manual control should not drastically vary throughout the way of moving the knots and parts of the machine by hand;

c) the operation of automatic devices, stops, dividing mechanisms should occur without fail and provide the necessary accuracy (for example, the repetition of the size when turning on the feed, with periodic division);

d) dead passage (gaps) in manual control feed screws should not exceed the limits set;

e) mechanisms of clamping of workpiece and tool - there should be no jamming and weakening of the clamping elements when repeatedly turned on, during overloads, etc.;

(e) The lubrication system must provide oil in certain quantities to all surfaces of the friction, both during the start-up periods of the machine and during its operation;

In this case, reliable operation of oil purification devices (filters, grids, etc.) should be guaranteed; Oil leakage through the connection of the oil line, flange connections, etc.;

g) the supply system of the lubricating and cooling fluid must provide sufficient continuous fluid supply to all service points of the working areas; Liquid leakage through the connection is not allowed in the cooling system;

c) the system of electrical equipment - for its trouble-free operation during start-up, stop, inhibition of electric motors, on the smoothness of the control of the rotational numbers of direct current motors, the effect of protective and emergency locks, and the reliability of the operation of the limit switches.

The presence and safety of the protective devices according to the safety precautions are checked.

Transmission of movements and operation of machine mechanisms should occur smoothly, without increased noise and knocking and without vibrations that cause fluctuations in the machine. It is recommended to limit the noise level in the machine tools in the service area by approximately 70 - 75 phonemes (this corresponds to the speaker volume of the speaker or speaker).

Starting and reversing mechanisms must occur without strikes and jerks.

Efforts on handles and handwheels of movement mechanisms when moving manually should not exceed 20 N for precise adjusting displacements in small machines (weighing less than 1 t), for precise adjusting displacements in medium-sized machines - 40 N, in machines of average for normal displacements - 80 N, in large Machines weighing more than 10 t - 160 N; in medium-sized machines at rare displacements - 160N.

In automated machines, with mechanisms for the implementation of cycles consisting of movements of different velocities (fast forward - working flow - rapid allocation), are checked:

a) accuracy of automatic devices during switching from one cycle to another;

b) absence of delays during the transition to the next cycle;

c) absence of impact at the moment of transition.

When testing a hydraulic drive, the latter must work without abrupt noise and hydraulic shocks in the pipes. All nodes of the machine, driven by the hydraulic drive, must move at all speeds without jerks.

5.6 Testing of machines in work under load

Testing of the machine under load should be carried out in conditions close to normal operation. During the test under load, the quality of work, the correctness and consistency of the operation of all elements of the machine is checked.

Tests under load are carried out by processing samples at the greatest effort of cutting, when the machine is loaded to the rated power of the drive and in the case of short-term overload of the drive electric motor by 25% over nominal power.

Test work under the load of universal machine tools is carried out depending on the purpose of the test machine on the draft or clean mode. If the machine can be used for both types of work, it should be tested in both modes.

During the tests of the machine under load, as in the case of idling tests, all its mechanisms must function properly; Vibration is not allowed, uneven speed of movement, slipping or overheating of friction clutches, knocking in the speed box, interruptions in the system of lubrication, cooling, electrical equipment, etc.

The number of spindle turns (or the number of dual turns per minute) at the nominal load of the machine specified in the passport (or in the order) shall not deviate from the idle speed for this speed by more than 5%.

During tests, the quality of clutches and brakes is checked. At maximum loads and overloads up to 25% over the rated power of the drive, the friction couplings must not be self-locking or slipping.

Safety devices must also be checked against their reliability and speed. If such a device has a cutting pin, then the compliance with the accepted specifications (material selection, heat treatment, etc.) is checked.

As a material for testing the cutting in most cases take steel 45 GOST 1050-74. For specialized, operating, aggregate machines, automatic machines, semi-automatic machines and other machines supplied to the customer with adjustment, as well as universal machines, for which the order provides for testing of the treatment of a particular part (according to the drawing or sample applied to the order), tests under load are carried out by processing this part.

When testing the machine in the work under the force of cutting, should use a cutting tool, normal for machines of the given size and for this type of processing. At testing in the work of specialized machines, automatic machines, etc. A special tool is also used. Cutting modes are selected depending on the type of work and must comply with the advanced standards.

When testing the machine under load, it is necessary to ensure that the fastening of the tool and the workpiece is rigid. Used cutting tool should be properly sharpened. The stability of the instrument during testing should not exceed the established limits.

High precision machines and machines for which the testing of the greatest cutting and twisting forces is not required are tested under load conditions.

5.7 Testing machine tools on productivity

Of course, only those machines in which the technical specifications or the order specify the specified performance, therefore, special, specialized, operating, aggregate, automatic and semiautomatic machines, as well as other machines, supplied with adjustment, are usually subject to testing for performance. In these cases, the productivity of the machine is determined by the number of pieces per unit time corresponding to the accuracy of the shape and size of the surface quality given technical specifications.

In the tests of special flat-grinding machines, polishing for sheet materials, grinding and polishing for pipes (for processing their inner surface), their productivity is determined by the area of the surface processed per unit time.

When testing on the performance of special machines it is necessary that the time required for processing each part (or unit of surface area) is the same.

All performance tests fall into the category of production tests, therefore, they must be carried out in conditions that are in accordance with the actual operating conditions of the machine. Therefore, the instruments and cutting modes used in these tests should be the same as when using the machine in the workshop conditions.

6. TESTING OF MANUFACTURING EQUIPMENT

6.1 Accuracy tests of machine tools for the machined parts production

The precision of the machined part depends on a number of factors, among which the deformation is most important in the resilient system of the machine - the workpiece is an instrument.

Efforts in the process of installing and machining the parts cause deformation of the part and the entire system. The deformations make changes in the relative positioning of the workpiece surface of the part and the tool, which is reflected in the accuracy of the machining and simultaneously restricts the cutting modes.

The choice of samples, cutting modes and tool for testing the machine for precision machining is carried out in each individual case in accordance with the type, size and design of the test machine. In this case, the cutting modes should correspond to the material of the workpiece and tools used for both roughing and finishing.

The tool uses the normal for the performed operation, correctly, and well-sharpened; its stability is determined by the established standards. Before starting the test, the instrument must be measured and the measurement results are recorded in the protocol. The fastening of the tool should be sufficiently rigid and exclude strain during the cutting process. The same applies to the shape, proportion of samples and to the method of fixing them on the test machine.

The material for samples is steel of medium hardness, most often - steel 45, or cast iron.

Before testing, samples must be measured and the measurement results are also recorded in the protocol.

For many machines, the shape and size of the sample for accuracy tests are provided "Norms of accuracy".

During the testing of the precision of the general lathe lathes, the following are carried out:

a) the grinding of a cylindrical shaft fixed in the cartridge and in a conical opening of the spindle (without the support of the center of the rear axle) of not less than 1/4 height of centers and not less than the height of the centers, but not more than 300 mm;

b) cutting the end surface of the workpiece in the form of a faceplate with a diameter not less than the height of the centers.

The treated shaft is checked for ellipse deviation and for taper with a micrometer.

The finished surface bored by the finishing mode of the faceplate is checked by plane, probe and measuring tiles. Allowed only bend to 0,02 mm with a diameter of 300 mm.

During testing of turning-threading machines of high accuracy, the corresponding tolerances are less. In addition, cutting is done with a subsequent check of the step cut by the optical device.

During the testing of drilling machines, instead of drilling, the spindle loading in the axial direction is carried out by an effort, which depends on the diameter of the largest aperture that can be drilled on this machine.

The load is measured by a dynamometer. In this case, vertically-boring machines verifies the perpendicularity of the spindle to the surface of the desktop, and in the radial-drilling - pressing the sleeve from the original position (indicator).

During the testing of horizontal and universal milling machines, three end-to-end milling cutters handle three perpendicular planes of the cast-iron sample, while checking the plane surface of the machined surface - with the help of a checking ruler, a probe and tiles, parallelism - an indicator, a perpendicular to the square - a square and a probe or an indicator.

During the testing of transverse and longitudinal-planing machines, planing a cast-iron bar (which has the shape of a rectangular parallelepiped), the sizes of which are chosen in the following limits:

1) for cross-planing - width and height not less than 100 mm, length not less than 200 mm;

2) for longitudinal-planing - not less than 350x350x1000 mm.

The plane of the treated surfaces, the parallelism of the top surface to the base and the perpendicularity of the treated planes are checked. Measuring tool - the same as during the testing of milling machines.

Tests of grinding machines are carried out according to the type of machine tool. For example, when testing simple circular grinding machines as a sample, a cylindrical shaft having a diameter equal to 1/4 of the largest machined diameter on the machine, but not less than 20 mm and a length equal to 10 diameters of the sample is used as a sample. The oscillation and conicity of the shaft are checked by a micrometer.

During the testing of the precision of the universal round-grinding machine tools:

a) clean grinding of a shaft in centers without lunette; its length must be equal to 1/3 of its length, but not more than 300 mm;

b) clean grinding of the hole clamped in the cartridge sleeve; the diameter of the hole should be equal to the half of the largest diameter of the hole, polished on this machine, and length - the largest length of the milling drill, but not more than 200 mm.

The absence of ellipse is checked, and the shaft is checked by a micrometer.

Inner grinding machines test the precision of work just like universal grinding machines when processing bushings. If the machine is also intended for face grinding, it is made of a single grinding unit of the hole and the end of the sleeve, clamped in a cartridge without lunette.

During the testing of the precision of the work of the grinding machines, several identical samples are placed on the grinding surface, installed in different places on the desktop. The supporting surfaces of all these samples should be thoroughly polished beforehand. After the test, check the relative height of the samples with a mini- meter or a precision micrometer. The error is defined as the largest difference in the height of the processed samples.

The test of the precision of the work of the tooth-blade and the gear-milling machines for cylindrical wheels are made by cutting the cast-iron rectangular wheel in the cutting mode. The width, the module of the tooth to be cut and the diameter of the wheel, are selected depending on the largest wheel diameter, which can be machined on the machine to be checked.

Measurements are checked:

a) the uniformity of the number of steps (the difference between the next steps) of the cut wheel;

b) beating the main circle;

c) the direction of the tooth (parallel teeth);

d) the precision of the tooth profile.

As measuring instruments apply: to check the step - universal tooth-meter or pedometer; to control the beating of the main circle - a special device with a saddle tip or a precise roller and indicator; To check the parallelism of the teeth, a long precision roller and an indicator with a special tip (with at least five hollows checking); To check the profile of the tooth - evoloventometer. Other devices are also used.

6.2 Verification of machine geometric accuracy

Static accuracy tests are carried out in the non-operating state of the machine. The purpose of these is the establishment of deviations:

a) from the correct form of surfaces (from straightforwardness, plane, cylindricality);

b) from the correct relative position of surfaces and lines (from parallelism, mutual perpendicularity, co-consistency);

c) from the correct movement (rotation without radial, without axial beating, straightforward motion, etc.).

Each of these deviations should not be greater than the permissible value provided for by the norm of accuracy for this machine.

Dynamic accuracy tests allow you to determine the achievable accuracy of the machined part, that is, to determine the accuracy of the machine in its working condition, as provided by the tests described above.

In static tests, geometric precision is checked mainly:

1) the correct installation of the machine, for which check the position of the main surfaces of beds, racks, plates, tables, columns, etc. (horizontal or vertical position);

2) straightness, parallelism, perpendicularity of guides where it is needed;

3) the plane of the guides, surfaces of tables, racks, faceplates, etc.;

4) the co-ordination of some parts, which ensure the accuracy of product processing (for example, the alignment of nests for instruments in the revolving head and spindle of the revolving machine);

5) parallel or perpendicular to the spindle axis to the plane of the table or the main plate;

6) radial and axial beating of various elements of the machine, for example, the neck and spine of the turning lathe, the radial beating of the axis of the conical opening of the table, the final beating of the working surface of the toothpick table.

During these checks, not only the magnitude of deviations, but also their direction is taken into account. The latter is to be foreseen when designing inspection schemes for each type of machine tool. This is dictated not only by the working conditions, but also the need to predict the effect of deformations under load and the gradual wear of surfaces.

6.3 Power testing of machine tools

Testing of a metal-cutting machine tool allows to estimate the design of the machine, to determine the quality of its manufacturing and assembly, to determine the effective power of the machine and its efficiency at the maximum permissible load at different degrees of speed of the main movement.

Testing the machine to power requires relatively simple measuring instruments and adaptations and can be carried out rather quickly. Different methods of testing machine tools on power are used:

1. Power test by the method of loading the machine by cutting with the definition of effective power calculation. For tests, rigid specimens, usually of medium hardness steel, are used.

The optimum cutting speed is chosen and corresponding to the selected sample material and speed - feed and cutting depth. Effective power is calculated by empirical formulas.

2. Tests on power by the method of loading the machine by cutting with the definition of effective power calculation with direct measurements. It differs in that the cutting force is determined here directly by measurement; so the accuracy of the determination is higher than with the first test method on power.

For carrying out of these tests it is possible to use dynamometers of various designs - mechanical, electric, hydraulic.

2. Tests on power by the method of loading the machine torque.

For this purpose, electric brakes such as balancing electric cars (dynamo-scales, motor-scales), which have a number of advantages: smoothness of work, simplicity of control of the brake torque, lack of water cooling, the possibility of energy recovery. The brake torque is determined by measuring the stator's reactive moment, which is equal to the magnitude of the moment applied to the rotor shaft. Typically, DCs with independent excitation are used to test the power as brakes.

Toughness system of the machine - the part - the device - the tool under the action of applied during the work of the forces is in a tense state. The forces of cutting, the pressure during fastening of the workpiece, the centrifugal forces that arise due to the unbalance of the rotating masses, etc., cause the deformation of individual parts of the system. The ability of the material to resist deformation is called rigidity.

Rigidity is one of the most important, often the most important characteristic of metal-cutting machine tools, since it depends on its accuracy and vibration resistance of the machine tool.

Research of stiffness of separate types of machine tools helps to find the most effective and economical ways to improve the operational properties of machine tools.

The rigidity of an individual component or knot is determined by its ability to resist the appearance of elastic deformations. In many cases, the stiffness of the part can be determined by the calculation of the formulas of the course "Resistance Materials".

Numerous experiments and observations in the shop conditions convincingly confirm the existence of a connection between the stiffness of the given system and productivity, since the choice of cutting mode strongly depends on the stiffness of the machine system - the workpiece is an instrument.

Knowledge of the total rigidity of the system is necessary for technological calculations of machine accuracy.

The working efforts in the cutting process tend to vary in size, since they depend on a number of variables (the size of the dropping force, the cutting edge of the tools, the method of fastening the workpiece, etc.), which also leads to a change in the stiffness of the system. Therefore, for verification of the machine the rigidity can not be limited to rigidity measurements for any one specific load: according to the rules of ГОСТ 7035-74, to the parts of the machine, the bearing tool and workpiece, load should be applied, gradually increasing to the specified limit, and simultaneously measure the relative displacement these parts. After bringing the load to a maximum, gradually unloading the corresponding knots of the machine and again measuring the relative displacement.

The conducted researches indicate that in studying the balance of the rigidity of the machine great importance is not only its own rigidity of its parts, but also the contact stiffness, in particular contact deformation of the tangential surfaces of the machine parts. Deformations of this kind play a large role in the machine tools, because they take place on those surfaces, on which depends the accuracy of the machine (guiding posts, racks, traverses, sleds, tables, etc., roller bearings in the supports of the spindles). The main factors affecting the contact stiffness of the machine are the accuracy of the shape and the cleanliness of the contacting surfaces.

Given the fact that the rigidity of the machine depends on its critical performance (performance, precision, vibration resistance), the test of rigidity of machine tools is becoming increasingly important. At the present time, a rigorous check is necessarily subject to each manufactured machine (in the factory-manufacturer) in accordance with the standard, which contains the rules of rigidity for machines of this size.

During the tests of the rigidity of the machine tools apply a method of static loading or loading by cutting.

For a static load you can use the mechanisms of the test machine or special jacks, and to measure loads - dynamometers. For this purpose, most often used dynamometers, the design of which is consistent with the type and size of the machine. Dynamometers allow you to reproduce the size and direction of cutting power or its component.

During the test of the machine on the hardness of fixing the press for a number of increasing values of applied forces. In general, pressing is not a linear function of the corresponding force. The dependence, obtained experimentally, in most cases can be expressed analytically with sufficient accuracy, but it is practically inappropriate or inconvenient for comparing the stiffness of the nodes. Therefore, stiffness is expressed by constant characteristics, which reflect the known approximation of the results of experiments and characterize the average stiffness of the corresponding node. When carrying out tests on one axis of the coordinates, set the value of the force, on the other axis - the magnitude of the clicks, thus obtaining in the general case the curve, which is then linearized.

When conducting rigidity tests it is necessary to take into account the influence of individual components of the cutting force, the diameter of the workpiece to be worked and other factors. For example, when turning the axial force Py tends to push the cutter back, and the vertical component of Pz causes the lowering of the vertex of the cutter and at the same time its displacement in the direction of the surface to be treated.

The resulting tensile strength also depends on the diameter of the workpiece to be processed; this is evident from the fact that with the same relation to the length of the shaft to its diameter, the stiffness of the shaft the larger the larger the diameter of the workpiece. In addition, it should be borne in mind that the diameter of the workpiece being worked has an effect on the position of the tool holder in relation to the frame guides.

Due to differences in the test method, the values of stiffness obtained during testing machines can be compared only if sufficient similarity, that is, the similarity of standard sizes of machines to be tested, the application of the same equipment, etc.

6.5 Testing of machine tools for vibration resistance

During the work of metal cutting machines, vibrations often occur, which in many cases limit the processing performance, cause increased wear of parts of the machine, have a very adverse effect on the stability of the tool.

Vibration strongly affects the quality of the treated surface as well as the accuracy of its shape and size. In addition, vibration, which causes more or less intense noise, leads to the fatigue of workers who serve not only this machine but also the surrounding machines.

The reasons for the occurrence of vibrations are diverse. The nature of the vibration observed during the machine operation depends on a very large number of factors, in particular on the cutting mode, the stiffness and condition of the machine, the type, the geometry and the state of the cutting tool, the properties of the material being processed.

There are two main types of oscillations during the work of metal-cutting machine tools:

1. Forced oscillations that can be caused: the work of nearby machines, for example, rhythmic strokes or shocks (resonant oscillations), unbalanced parts of the machine, rotating or machined workpiece, peculiarities of the drive operation or its disadvantages (the errors of the gear and chain transmissions are bad the connection of the ends of the belt, the effect of the cross and hinged couplings, the fluid pulsation in the elements of the hydraulic drive, etc.), the intermittent nature of the cutting process.

2. Auto-oscillations, occurring in the absence of periodic external force and brought by the power of cutting. The amplitude of oscillations of this kind depends on

the properties of the system - its rigidity and the masses of elements that it contains. Acquiring the energy required to maintain a vibrational state is controlled by the system itself. Self-oscillations in cutting may be caused, for example, by the dependence of the cutting force on the cutting speed, the change in the force during the cutting of the incisor in the metal and its exit, the different conditions of the formation of the onion on the cutter, the fluctuations in the cross-sectional area and other reasons.

The harmful influence of vibrations during cutting on the quality of manufactured products, the productivity, stability of the tool makes it necessary to at least a general overall qualitative assessment of the vibration resistance of the machine and finding ways to prevent vibrations and eliminate them in case of occurrence.

The main measures to increase the vibration stability of projected machines are:

1) increase the stiffness of the machine, which sometimes turns out to be a decisive factor in the given relation;

2) increasing the ability of the system to dampen oscillations by applying dynamic vibration dampers, material parts with high internal friction (cast iron, textolite, concrete, reinforced concrete);

3) good dynamic equilibrium of all parts of the rotating machine.

Eliminate the vibrations that arose in the process of the machine, can be done by:

1) Adjustment of spindle bearings, guides, joints in order to eliminate unnecessary gaps in conjugation and thus increase rigidity;

2) more thorough installation and balancing of the workpiece to be processed;

3) change of instrument;

4) change the cutting mode, which is undesirable, since this measure reduces the productivity.

The foundation for the unbiased work of machines is of great importance. A rational means of preventing fluctuations is the correct choice of cutting mode. In relation to the fight against vibration is beneficial:

1) switch to high-speed cutting, if its mode is allowed to drive;

2) When working with tools with a negative front angle, the cutting speed should be at least 100-150 m / min.

3) Avoid thin chips.

The fight against fluctuations at the expense of a cutting tool, without reducing its stability, is achieved by selecting the appropriate geometry, providing sufficiently high purity of the surfaces of the working faces of the tool, due to the rigidity, the choice of material with large internal friction (for example, the use of hardboard borshtang for work on diamond-boring machine tools).

Sometimes the cause of vibrations in the cutting process is the unsuccessful choice or incorrect use of the device (for example, the clamping device). It is necessary that the processed workpiece is clamped as close as possible to the treatment site and, if possible, to the maximum number of points. It is recommended to use cartridges with increased clamping force, statically and dynamically balanced, reliable lunets, sufficiently rigid centers, etc. It is necessary to ensure that the releases of the mounting elements are minimal.

The vibration resistance of the spindle assembly, which is installed in the bearings of slip, may be increased by previous spin-on at low speeds with subsequent adjustment of the supports.

Rolling bearings, especially in spindle supports, must be fitted with a preliminary tension. Good regulation of the guiding motions for all machines is especially necessary in the plane, the movement of which directly affects the accuracy of the processed product.

Effective means of combating vibrations arising in the process of cutting are vibration ducts - devices that allow the elimination of vibrations in place. Vibrations are installed on the machine. Friction vibrations are based on the principle of increasing the vibration stability of the machine system - the part - the tool due to internal friction in some elements of vibration, and vibration damaging of impact action - on the principle of energy dissipation of oscillations when collisions of bodies with not completely elastic materials.

Testing of machine tools for vibration resistance is carried out during its run-off and under load, and with the help of appropriate devices are registered:

1) roughness of the processed surface of samples - with the help of a profiler;

2) the frequency and amplitude of the oscillations of the corresponding elements of the machine during the occurrence of excessive vibrations - vibrographer or torsiograph (for torsional oscillations);

3) the frequency of internal oscillations of the working bodies of the test machine - an oscilloscope; (these vibrations are excited in the usual way, for example, a blow that causes fading oscillations).

The results of the records often make it possible to find out the source of insufficient vibration resistance of the machine tool and make corresponding corrections in the design.

Oscillation frequencies can be determined with the help of the simplest devices - tongue frequency meters, whose action is based on the principle of resonance. The most common frequency of the Fram system consists of a set of plates (tongues) of different masses and elasticity, which, because of this, have different frequencies of their own oscillations. When the frequency of the oscillations of the studied element or the machine with the frequency of its own oscillations coincides with any plate of the frequency meter, the plate begins to vibrate.

They are often used for mechanical, optical, or electrical vibrations for this purpose.

7. SYSTEMS OF TECHNICAL DIAGNOSTICS OF AUTOMATED MACHINES

Further increase in the degree of automation and expansion of the functional capabilities of modern automated technological equipment, especially machines made of CNC and built on their basis HVM and GVS, require a significant complication of the design of the machines, as a result of which their maintenance and especially the search for the causes of failures are essentially complicated equipment in operation.
If the possible causes of certain failures that occur during the operation of universal technological equipment are, as a rule, few and they are often known or easily determined, then the reasons for the failure of automated machines, which include complex interacting mechanical, hydraulic, pneumatic, electrical and electronic mechanisms, devices and blocks, there can be a lot of them, and in connection with this, their detection requires significant expenditure of time and money. As a result of significant downtime caused by the need to find the causes of malfunctions, the work productivity and efficiency of this rather expensive equipment decreases. These problems are further complicated by the high intensity of operation of automated machines, which often work in three shifts with a minimum number of service personnel.

Processing of blanks on automated equipment is usually carried out with the use of modern cutting tools and high-performance cutting modes, which leads to an increase in the load on various mechanisms and devices of machines.
Thus, the probability of failures of automated technological equipment and its control systems is higher than for universal machines, and therefore it takes more time to find the reasons for these failures.

As practice has shown, the causes of a significant number of failures of automated equipment can be quite simple, but the time required for their search is often an order of magnitude greater than the time for eliminating failures, even when highly qualified adjusters or operators are involved for this purpose. Therefore, technical diagnostics systems are becoming more and more widespread, which are especially effectively used in the operation of modern CNC machines, as well as HVM and GVS. Technical diagnostics means determining with a certain accuracy the technical condition of the machine and its control system as a whole, as well as the condition of their individual nodes, mechanisms, blocks and elements. The result of the diagnosis is a conclusion about the technical condition of the machine or its element, indicating, if necessary, the locations, types and causes of the detected defects.

The use of technical diagnostics systems makes it possible to significantly reduce idle equipment during the search for its malfunctions, makes it possible to predict the state of individual elements of the technological system (workbench, PCPK, cutting tools), evaluate errors of processed workpieces and receive information in time for implementation quality maintenance and repair.

The technical diagnostics system is, as a rule, part of the control system of this specific technological equipment and in most cases has common information channels with it.

Technical diagnostics systems are intended only to detect malfunctions, but not to eliminate them. Therefore, the use of such systems does not directly increase the reliability of machines, although it allows to quickly determine the location and nature of defects, reduce downtime and increase the productivity of equipment.

In the event of critical situations that threaten, for example, a cutting tool breakdown, a change in the parameters of the operation of individual blocks of the control system, going beyond the tolerance field of the dimensions of the processed workpieces, the technical diagnostics system gives a command to the technological equipment, and when applying modern CNC systems - displays information about the type of defect.

During the operation of the automated equipment, working and test effects can be applied to it from the side of the diagnostic system (the latter are provided for the purpose of obtaining information about the technical condition of the machine).

When creating a system of technical diagnostics, it is recommended to be guided by the following basic principles.

1. The technical diagnostics system should be an integral part of the overall control system of the technological equipment (PCM machine) and should be created on the same methodological and elemental basis with it, so that common information channels can be used in the process of their operation. To obtain diagnostic information, it is necessary to use the available devices of the control system as fully as possible. In addition, the PCPK must be equipped with a self-diagnosis system that must work according to the block of test programs.

2. The technical diagnostics system must function effectively not only during the operation of technological equipment, but also during its adjustment, preparation and repair.

3. The technical diagnostics system, in terms of its functionality, structure and used technical means, must correspond to the degree of automation of the workshop or enterprise where the machine being tested is operated. In the case when this specific equipment is built into a flexible automated line, site or workshop, its technical diagnostics system, along with the control system, should be included as a component part of the general production control system.

4. Diagnostic information must be sent to the central service point of technological equipment in a decoded and user-accessible form. The necessary part of the information should be recorded in the memory devices with the time, day of the week and date of receipt for the purpose of its further analysis, as well as forecasting the state of the technological equipment, its separate nodes and mechanisms. If there is a central computer at the enterprise, the specified information should also be sent to it.

5. In case of necessity, the receipt of diagnostic information must be accompanied by the provision of acoustic and (or) optical signals. During the development of the diagnostic system, it is necessary to study in detail all possible malfunctions that may occur during the operation of this particular machine, as well as carefully analyze their causes and consequences. At the same time, it is necessary to focus attention first of all on those malfunctions, for the elimination of which a maximum of time and money are required.

According to the general structure of the technical diagnostics system developed in [11], it is recommended to implement it in the form of five subsystems: "Control of readiness of technological equipment for work"; "Operative cyclic diagnostics"; "Operative nodal diagnosis"; "Special diagnostics"; "Diagnosis based on the results of workpiece processing".

If the diagnostic system is created to determine the state of the automated equipment, then in the subsystem "Control of the readiness of the CNC machine tool for work" using such tools as limit switches, blocking relays, pressure sensors, float relays and others, the accuracy of the installation is checked workpieces on the machine and tools in the shop, pressure measurement in the hydraulic systems of the main drive and supply, lubrication, supply of ZOR, as well as in the pneumatic system, control of the presence of the necessary amount of working fluid in the tanks and reservoirs of hydraulic systems.

Generalized information about the readiness of the machine is displayed on its control and diagnostic panel, on the display of the computer system of the higher level of control, and on the dispatcher's panel.

In the subsystem "Operational cyclic diagnostics" with the help of limit switches, relays, measuring transducers of feedback systems according to the position of executive elements and timers of the machine control system, a generalized assessment of its technical condition is carried out, as well as an immediate search for places and causes of failures or failures during the execution of the given control program by the equipment. At the same time, the actual duration of the work cycle and its individual stages is controlled (for example, the time to turn one step of the tool magazine, tool edger, table). The obtained deviations of the actual values of the parameters from the calculated values are analyzed, and on their basis changes in the technical condition of the machine components and mechanisms that ensure the performance of this stage of the cycle are predicted. The number and duration of downtimes for organizational-technical reasons and others are also taken into account.

At the moment of receiving a signal that the duration of one or another stage of the cycle exceeds the permissible one (the latter is equivalent to the occurrence of a "failure" or "failure") situation, information is displayed directly or in coded form on the control and diagnostic panel or on the display of the PCPK -tion about the place of failure or failure. Their cause is determined by the machine itself during a preliminary logical analysis or by a human operator based on fault tables.

The "Operative nodal diagnostics" subsystem is used in cases where the capabilities of the two subsystems considered above are insufficient. As a rule, this subsystem is triggered when the machine malfunctions. As means of control, it uses test programs for diagnosing PCPK, devices for receiving signals from the control elements of the drives of the main movement and feeds, as well as devices for the machine's electrical automation. In addition, the subsystem serves to determine the technical condition of the nodes and mechanisms of the machine, as well as the PCPK blocks that ensure its functioning according to the specified program.

Data on the causes of failures and recommendations for their elimination are displayed on the PCPK display screen. In the event of a PCPK failure, a self-diagnosis operation is carried out with the help of the computer system built into it. In the case of impossibility of carrying out the latter, a higher-level computer control system is connected, which diagnoses the PCPK.

The "Special methods of diagnosis" subsystem is used to perform complex diagnostic operations using special devices, the permanent functioning of which in the machine is not practical for technical and economic reasons. Therefore, these devices are installed on a separate mobile platform and are connected to the equipment by flexible communication channels. In this case, a higher-level computer control system is used for diagnosis.

Thanks to wide diagnostic possibilities, the considered subsystem provides definition and analysis of the technical parameters of the machine, which characterize its performance (positioning accuracy, contour bypass accuracy, frequency characteristics of the drives and the supporting system of the equipment, the accuracy of its geometric parameters, as well as rigidity kinematic pairs, gaps in them, friction forces, degree of wear, etc.). Based on the analysis of the changes in the actual characteristics and their comparison with the normative values, the probability of maintaining the machine's operability during a certain period of time (functional and parametric reliability) is predicted.

The "Diagnostics based on processing results" subsystem provides control over changes in the state of those nodes and mechanisms of the machine tool, the accuracy of which directly depends on the accuracy of the products (deviations of the values of the actual design parameters of the machine tool from the specified ones, wear of the guiding elements of its executive elements, temperature deformations or heating of the basic parts are checked , wear of the cutting tool, etc.).

When processing workpieces in the conditions of highly automated production, it is especially important to control the state of the cutting tool (its current wear and presence of breakages). It can be performed with the use of contact and non-contact sensors of the optical, electric or pneumatic type both during the mechanical processing of the workpiece and after its completion.

In the case of an intermediate assessment, the cutting force, the spindle torque, and the power of the main drive are measured. At the moment of reaching the maximum allowable values of the specified parameters, the diagnostic system gives a command to change a dull or broken instrument, or ensures a stop of processing. However, nowadays there are still few reliable sensors that can be used to carry out the described control role. Therefore, average evaluation is still rarely implemented in practice.

As it was shown above, the tasks of technical diagnostics can be different, therefore, the control of certain parameters of the equipment is carried out more often or less often, depending on the specific production conditions and requirements for its operation (Fig. 4).

Diagnostics can be carried out continuously (Fig. 4, a) during the entire time of machine operation and workpiece processing. According to such a law, for example, the temperature in the PCPK cabinet or the temperature of the working fluid in the hydraulic system of the machine and other characteristics are controlled. A number of parameters, for example, the functional characteristics of the centralized lubrication system, the effort of fixing the workpiece and the accuracy of its processing, should be controlled periodically (Fig. 9.1, b), but with a high frequency. Some of the control operations are carried out with a lower frequency, for example, once per shift or after the completion of processing of the next batch of products (Fig. 4, c).

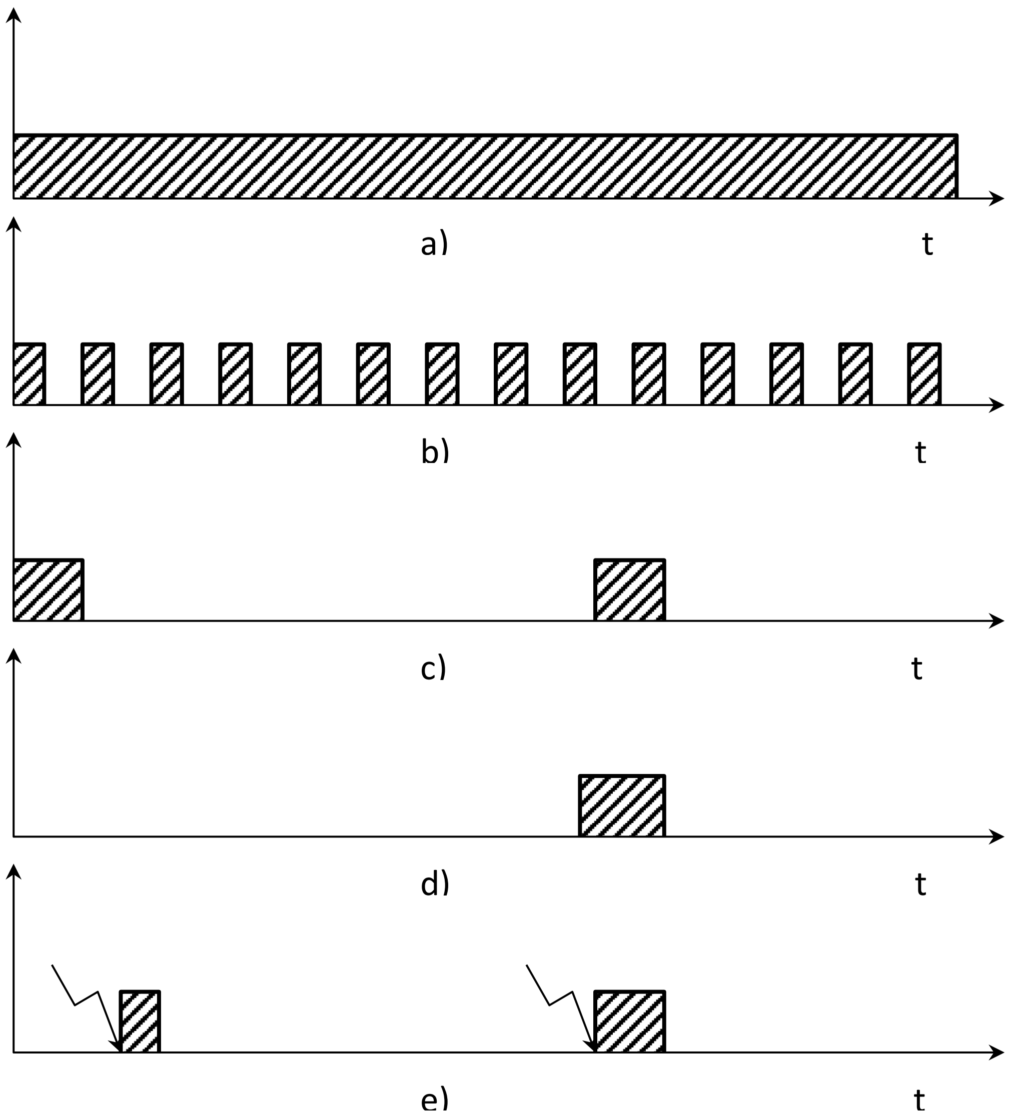

Figure 4- Variants of diagnostics during operation: a – continuous diagnostics; b, c, d – intermittent diagnostics with high, medium and low frequencies, respectively; e - diagnosis on demand

Such characteristics of the machine tool as the accuracy of its geometric parameters, kinematic accuracy, stiffness and others can be monitored over long periods of time with a relatively low frequency (Fig. 4, d), because they change very slowly, while the measurement of these parameters requires considerable time and funds. In some cases, diagnostics can be carried out at the operator's decision and command, depending on specific requirements and conditions (Fig. 4, e).

8. OPERATION OF ASSEMBLY MACHINES AND AUTOMATIC LINES

8.1. Features of operation of automatic lines

Ensuring the rational operation of aggregate machines and automatic lines based on them is of particular importance, since the failure of only a part of the equipment leads to downtime of the entire line and a sharp decrease in its efficiency. In this regard, a comprehensive solution to the problems of maintenance, repair, control of the main functional and operational parameters, as well as control of automatic lines is necessary. Maintenance of the automatic line includes operations to maintain the equipment that is part of it in working condition, including: delivery to the workshop where the line is operated of blanks, tools, equipment, working fluid, PPE, etc. in quantities that ensure its uninterrupted operation; maintenance of equipment; timely detection and prevention of malfunctions; elimination of the simplest defects by replacing or restoring failed parts or components. Maintenance of automated machines must be planned, otherwise the frequency of equipment failures increases sharply, its durability decreases, and operating costs increase. The main document that determines the scope and sequence of maintenance work on automatic lines is the plan-regulation. The blanks are delivered to the line in a unified returnable container, which provides the possibility of using forklifts for their transportation, as well as multi-level storage in stacks and on racks.

Equipment preparation also plays an important role. The condition of those equipment elements that have a relatively short service life (conductor bushings, locking fingers, base bars, etc.) is checked every day before starting the line; of course, they are subject to replacement in a planned manner. In order to reduce the time of checking the position of wear-and-tear elements, special devices are used to adjust them off-line.

The problem of its uninterrupted supply with a tool also has its specificity when operating an automatic line. The specified specificity consists in the number of types and types of tools, simultaneous operation of a large number of tools, significant fluctuations and shortening of their stability periods in comparison with a similar parameter of tools working on universal equipment, as well as in the rhythmicity and repeatability of changeover operations. To reduce downtime of the equipment, sub-adjustment of the tool position is usually carried out with the help of special devices developed in parallel with the design of the tool equipment. Only a standardized, quick-change tool can be adjusted outside the machine tools. The shape of the surfaces of the standard used for setting up the tool must correspond to the configuration of the surface to be processed, and its hardness must be equal to or only two to three units of HSC lower than the hardness of the working part of the tool.

The replacement of a worn tool with a new one is carried out according to the following main features (criteria): approximation of the actual deviations of the size of the products to the specified limit of the tolerance field; output beyond the permissible values of the actual values of the components of the cutting force or torque (registered with the help of special built-in sensors); tool failure; the number of cycles used by the tool has reached the normative value or, according to the forced replacement schedule, its resource has been exhausted. Other criteria for blunting of the tool (for example, a change in the color of the rising chip, non-characteristic squeaks or whistles during operation, non-normative appearance of the machined surface) in the conditions of automated production are of secondary importance and are taken into account by the adjuster when determining the need to replace the tool only as additional minor signs.

In order to increase its reliability and dimensional stability, slightly lower standards of permissible wear are established for the tool of the automatic turning line than for the tool used on universal equipment. Forced replacement of the tool in the workshop, where the automatic line is operated, is introduced only after regulating the normative periods of stability and periodicity of the supply of the tool to workplaces.

The entire amount of work on technical maintenance of the automatic line is divided between several adjusters, while each of them is responsible for servicing the equipment located in a certain area. For individual instruments of each zone, the values of stability periods are adjusted based on specific operating conditions and their average values are established; the entire instrument is divided into groups according to the value of the period of stability and schedules of its forced replacement are drawn up. According to the specified values of the periods of stability, the norms of consumption of the tool are determined, as well as the norms of its stock in the tool store.

Maintenance of hydraulic systems and equipment lubrication systems of automatic lines consists in periodically replacing the working fluid in them, replenishing it in tanks and reservoirs, checking and regularly cleaning the systems, etc. Modern automatic lines are equipped with centralized flow lubrication systems of various structures with means of active control of their main operating parameters, which ensure the supply of a regulated amount of lubricant and in which the possibility of regulating the periodicity of supply is provided. When the lubrication system is operating in automatic mode, the time interval between two successive lubricant supply pulses is selected so that an oil film would remain on the friction surfaces of mutually moving parts until the moment of the next pulse.

Maintenance of the automatic line also involves periodic care of the waste feed systems, collection and removal of chips, cleaning of the equipment, cleaning of the area around the line, etc.

During the operation of the automatic line, the service personnel actively monitors the condition of the machines, receives relevant information and, if necessary, takes measures to prevent the failure of parts and equipment components, and if they occur, immediately stops the operation of the line. The adjuster is obliged to constantly monitor the signals of lamps, remote controls and other devices of light, sound and digital indication, the condition of the mechanisms of machine tools and transport devices, periodically check their operation; control the condition of the cutting edges of the tools and the quality of the processed products; monitor the operation of the hydraulic system, check the pressure and temperature of the working fluid, the absence of its leaks; constantly monitor the correctness of the removal of the chips, the supply of ZOR (especially the direction of its flow); control the filling of storage devices and the actual duration of the operating cycle of the equipment.

To facilitate control over the state of machines in automatic lines, various diagnostic methods are widely used, as well as devices that record the parameters of the actual technical condition of the controlled element and transmit the specified information to the display.

Effective operation of the line requires increasing the accuracy and reliability of receiving information, on the basis of which decisions are made on the management of the machines and their maintenance. As production experience has shown, an increase in the number of service personnel does not provide a substantial increase in the rationality and speed of solving line management problems, therefore, to facilitate the collection and processing of information about the actual values of the functional and operational parameters of the equipment, it is advisable to use a computer a technique that allows you to quickly adjust the equipment and equipment depending on their actual condition and to carry out a more rational operation of the automatic line in general.

With the help of a computerized system of operation of an automatic line, the following main tasks are solved: control of machine work cycles; accounting for their downtime; control over the working cycle time and identification of equipment malfunctions; accounting for the release of suitable and defective products as a whole along the line and for individual machines; formation and issuance of information on stock management of blanks, tools, lubricants, etc.; control of the condition and replacement of the tool; formation of long-term information for maintenance and repairs of equipment; preparation, transfer and exchange of information with ASUP.

8.2. Maintenance of automatic lines

The number of adjusters and operators serving the automatic line is determined during its design and specified during operation.

For lines with a rigid connection, the number of service personnel should be greater than for lines with a flexible connection (the latter, as a rule, are serviced by one operator and one adjuster), because in the first case, stopping one machine leads to downtime of the entire line - them The main starting parameter when determining the optimal number of adjusters is the time required to ensure high-quality organizational and technical maintenance of the line.

In addition, when determining the number of adjusters, such parameters as:

- the number of serviced machines and their reliability;

- the number of cutting tools and their stability (it should be remembered that the actual stability of the tool may differ significantly from the calculated one [12]);

- the number and reliability of auxiliary equipment (bunkers, stores, control devices, etc.);

- distances between serviced machines or sections;

- terms of operation of machines;

- equipment cost.

Studies, conducted for typical operating conditions of automatic lines from aggregate machines, show that in cases where the coefficient of technical use of one section is 0.9 ÷ 0.95, it is most profitable to involve one adjuster to service two sections. If the utilization coefficient is less than the specified value, then each site must have its own adjuster. In some cases, with low reliability of the equipment, it is advisable to use two adjusters to service each section of the line. Thanks to the reduction of downtime and the increase in the productivity of the line, even with the increased salary fund of the personnel serving it, the cost of processing blanks is reduced.

The following conditions of operation of an automatic line of aggregate machines are considered typical, under which:

- the relative cost of the equipment included in its composition is equal

$$\mathbf{k = C_1 / C_p,}$$

where $\mathbf{C_1}$ is the cost of one section of the automatic line;

$\mathbf{C_p}$ – the annual wage fund of one adjuster;

- the ratio of the duration of movement of the adjuster in the area of the site for the purpose of monitoring the operation of the line to the average net time of troubleshooting $\boldsymbol{\alpha} = 0.5$;

- the ratio of the preparatory and final time spent in servicing one machine during a shift to the variable time fund $\boldsymbol{\beta} = 0.06$.

For lines with a flexible connection, it can be considered that in cases where the co-efficient of technical use of one machine η_{TB} = 0.75 ÷ 0.8, the most profitable is the organization of service by one adjuster of four machines; at $\boldsymbol{\eta_{TB}}$ = 0.7 ÷ 0.75 – one adjuster can effectively service three machines; if $\boldsymbol{\eta_{TB}}$ = 0.6, each machine must be serviced by a separate adjuster.

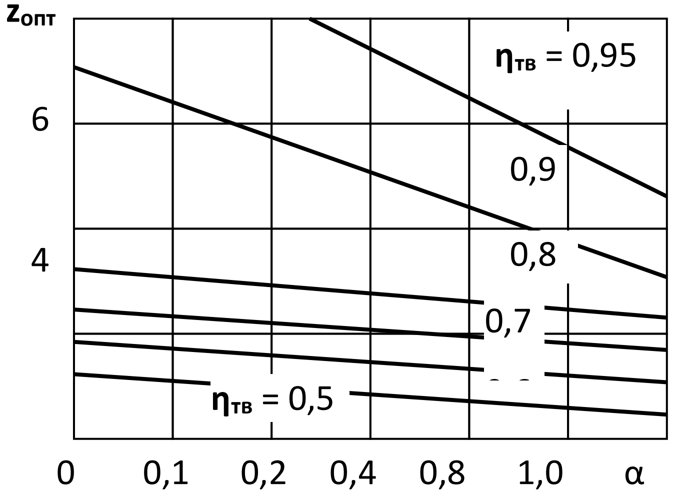

Figure 5 - The dependence of the optimal number of machines in a line serviced by one adjuster on the reliability of the equipment

In fig. 10.1 shows the dependence of the optimal number of machines z serviced by one adjuster on the size of the service area and the reliability of the machines in operation. The distance between machines or sections of the automatic line is of significant importance only when servicing equipment with a high coefficient of technical use. The coefficient α takes into account not only the time of the adjuster's transition to the machine that failed, but also the time to identify the malfunction.

According to the experience of the Moscow Carburetor Plant, the optimal number of assembly machines that can be effectively serviced by one adjuster should be z = 6 ÷ 8. The optimal number of operators is determined depending on the design of the line, mass and overall dimensions of the processed workpiece.

The lines must be serviced by adjusters who have undergone special training and have a qualification corresponding to the 5th - 6th category. The adjuster must know the structure of nodes and mechanisms of line equipment, hydraulic and pneumatic devices, methods of their adjustment and adjustment, used cutting and auxiliary tools, factors affecting processing accuracy, etc.

The adjuster must be able to find the cause of the malfunction and eliminate it in the shortest possible time, in connection with which he must be well aware of the sequence of interaction of all nodes of the automatic line.

The adjuster must constantly monitor the quality of the processing of the workpieces, the condition of the basic surfaces of the devices and the cutting tool, its operation, the functioning of the lubrication and chip collection systems.

The automatic line should be regularly cleaned of dirt and shavings, so it is necessary to allocate general workshop maintenance personnel to help the adjusters. Cleaning should be done after the end of the second shift, and line transfer should be done on the go in the presence of the senior adjuster. Thanks to such an organization, downtime due to certain delays in the flow of the working fluid into the cavities of the hydraulic motors, the beginning of an increase in pressure in them, and the movement of the executive elements after giving the appropriate commands is reduced.

The staff of the maintenance personnel of the automatic line should include a senior adjuster, whose duties are to monitor the operation of the entire line, issue orders for repair work and accept the line after repair, check the correctness of the placement of workers on the site, the timeliness of the supply of cutting tools, the quality of line cleaning, the sequence of operations for replacing emulsion, lubricants, cleaning filters, etc.

The senior adjuster must also keep a log of line downtimes, indicating their duration and reasons. In addition, in this journal, it is necessary to indicate what preventive and repair work was carried out, who performed it, as well as what are the results of checking individual units before installing them on the line.

If some or other mechanisms of the line fail too often, the senior adjuster should write a memo to the workshop (plant) mechanic with a request to replace or repair them. In addition to comments on the reliability of nodes, the senior adjuster evaluates the functioning of the line and gives recommendations, following which, in his opinion, the convenience of maintenance and adjustment of both individual mechanisms and the line as a whole will be increased.

8.3. Organization of the workplace of the automatic line adjuster

When organizing the workplace of the automatic line adjuster, it is necessary to ensure the convenience of the approach and work on it, as well as the air temperature, humidity and lighting regulated by the Standard System.

The workplace should have a working or tool cabinet (sometimes both cabinets are needed).

The tool cabinet stores a set of used cutting, auxiliary, and control tools, as well as tools, lubricants, and wiping materials necessary for the robot adjuster.

The scheme of the tool cabinet for automatic lines, in which the counter and signaling devices, the system of forced replacement of the cutting tool are installed, is shown in fig. 10.2. On the front side of the cabinet, slots are made for storing the tool adjusted outside the machine tools and holders for it. The number of sockets corresponds to the number of cutting tools used simultaneously during the operation of the automatic line.

The entire tool line is divided into five groups with endurance periods of 600, 1200, 2400, 4800 and 9600 cycles.

At the moment of starting the automatic line, the cycle counter 1 is turned on, from the solenoid of which, through the lever mechanism, the counter for tools of three groups is rotated.

After the automatic line has completed the first 600 processing cycles, the arrow of the counter 2 installed on the panel 3 will make a full revolution, as a result of which the signal lamp 4 will light up, indicating the need to replace the tools of the first group. In this case, the line should be stopped (sometimes an automatic stop is made) and the entire tool of this group should be replaced. After working through the next 600 cycles, the tools included in the first and second groups, etc., are replaced. The tools replaced at the previous stage pass through the stages of disassembly, washing, inspection, control, sharpening, restoration, repair and preliminary adjustment outside the machine, the execution of which is combined in time with the operation of the line.

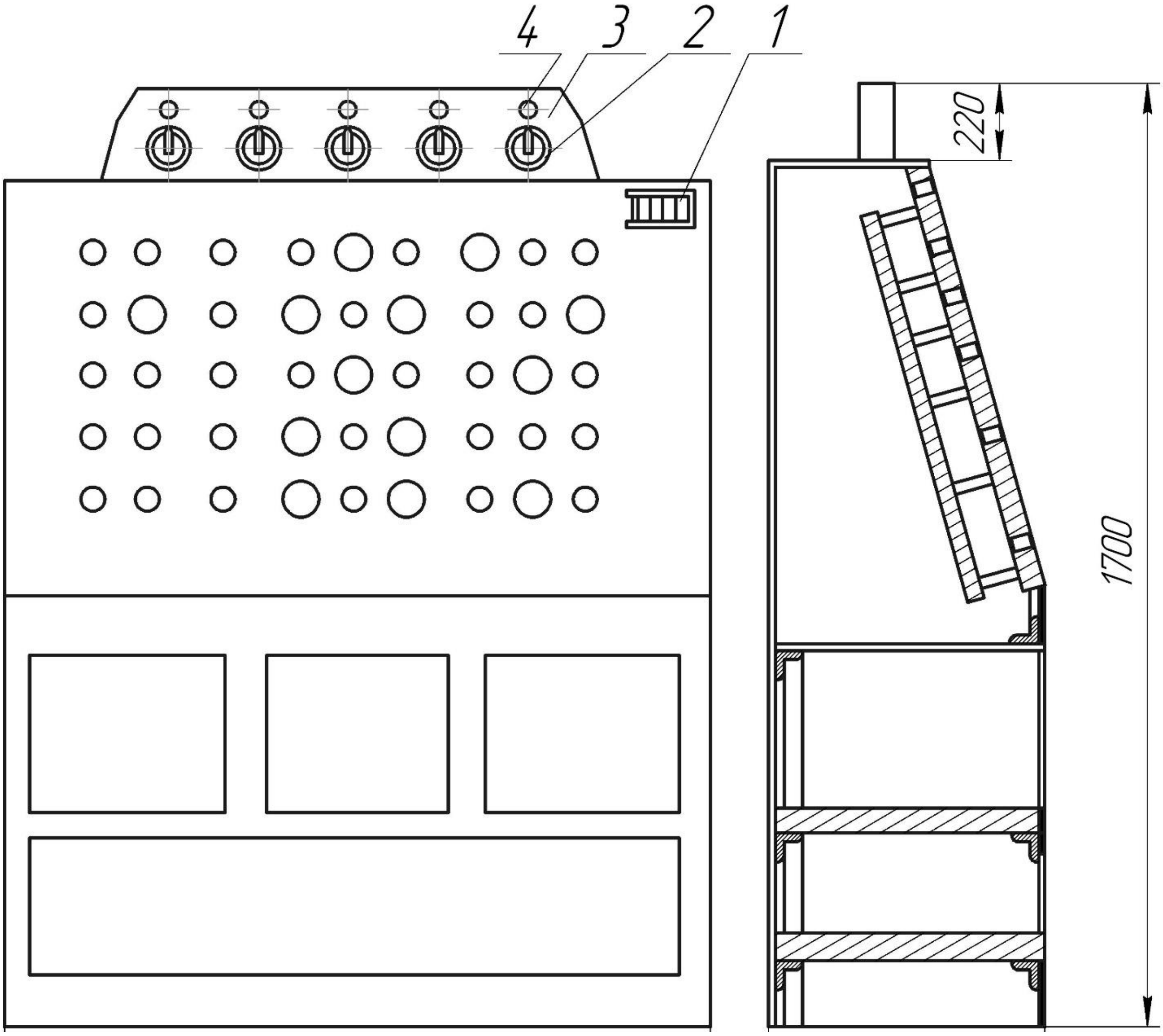

Figure 6 - Instrument cabinet with counter and signaling devices

The tools that, according to the technological process, are necessary for the processing of this specific workpiece, must be at the workplace in the amount that corresponds to the technical documentation.

After removal from the machines, the cutting tools must undergo centralized sharpening, after which the actual geometric parameters of their working part must correspond to the specifications indicated on the sketch. The use of a tool with an inappropriate geometry of the working part can lead to a reduction in the period of its stability and the number of resharpenings, as well as to a deterioration in the quality of product processing.

Control instruments must undergo mandatory testing according to the schedules of the enterprise's central measuring laboratories (CML). The necessary number and nomenclature of wrenches, screwdrivers, hammers and other tools are determined taking into account the nature and volume of debugging work, the type of fasteners and other specific data about the equipment being serviced.

Tools should be stored in cases made of dense fabric or derma-tin and delivered to the place of adjustment in special portable boxes.

8.4 Prevention and stable conditions operation of automatic lines

For the stable operation of the automatic line, it is necessary to periodically carry out preventive inspections and repairs of its equipment, as well as comply with a number of mandatory requirements.

The main prevention requirements include the following: regular lubrication of friction surfaces and maintenance of specified levels of working fluid and lubricant in tanks and reservoirs of hydraulic systems; application of lubricants in exact accordance with the operating instructions; regular control of the operating temperature of sliding and rolling bearings; timely replacement of cutting tools and parts that wear out quickly; periodic monitoring of the operation of way switches, blocking devices, pneumatic and hydraulic valves, flow regulators, throttles; timely replacement of PPE; regular check of reliability of fixation of processed workpieces and cutting tool; maintenance of chip removal systems, as well as loading and unloading devices; checking the quality and accuracy of assembly of machines after repairs, ensuring their protection against corrosion, etc.

Scheduled repairs of automatic line equipment are mainly performed on non-working days. In the repair department of the workshop in which the line is assembled, there should be a sufficient supply of parts that wear out quickly.

Repair of machines of the automatic line should be carried out using the aggregate method (see section 6.2), replacing completely separate units, power heads, nozzles and satellites even in cases of failure of only one or several elements. At the same time, the duration of repairs is significantly reduced and the technological reliability of the machine (line) is maintained.

Individual units must be repaired, tested and prepared for assembly by a special group of mechanics.

For normal operation of the line, the following requirements must be met:

1. Voltage fluctuations in its power supply system should not exceed +15%, -15% of the nominal.

2. The compressed air pressure in the pneumatic network should not be lower than 0.4 MPa.

3. Compressed air must be supplied to dry-dry and clean control equipment.

4. Cooling water in heat exchangers should have a temperature of no higher than 16 ÷ 18 °C.

5. The blanks processed on the line must comply with the technical conditions for delivery and have dimensions that are acceptable for deviations from the given ones.

6. The stability of the cutting tool must correspond to the calculated one.

8.5. Operation of the cutting tool

In the process of mechanical processing of workpieces, the working part of the cutting tool wears out. It is known that at the initial stage of the tool's operation, the process of its wear occurs relatively slowly and evenly over time, and in the future - accelerated. The most rational is to replace the tool at the end of the period of its normal wear and tear.

In production conditions, it is quite difficult to determine the moment when tool wear reaches the maximum allowable value. According to the provisions of the theory of metal cutting, the main criteria for maximum permissible wear are:

1. Power criterion. Blunting of the tool becomes unacceptable if the cutting force on it increases sharply. This criterion is quite objective, but special devices are needed to control the components of the cutting force. If the latter are available, it is possible to implement automatic sub-adjustment of cutting modes during processing.

2. Criterion of a shiny strip. The tool is considered dull if a shiny strip appears on the machined surface of steel parts, and dark spots appear on cast iron parts. These

stripes occur as a result of friction between the worn back surface of the tool and the processed surface of the workpiece. However, the described criterion cannot be used in all cases. For example, it is unsuitable for processing with a carbide tool, as well as for drilling small diameter holes.

3. Technological criterion. Tool wear is unacceptable if the accuracy or cleanliness of the surface treated with it does not meet the requirements. This criterion is decisive for fine processing, and is not used at all for rough processing.

4. Criterion of linear wear. The tool is considered worn if the wear on its rear surface or corners reaches a certain value specified in the reference tables [12]. In production conditions, the actual stability of the tool and the average number of cycles, after which it should be replaced, can be determined based on these values.

It is also necessary to take into account that when working at lower cutting modes, tool wear occurs more smoothly, which allows, in cases of their operation on automatic lines, to replace the tool with a value of actual wear greater than the table value.

During the operation of automatic lines, two main tool replacement systems are used: individual and group. With individual replacement, each of the tools is used only until its wear reaches the maximum allowable value. The disadvantage of this system is the need for frequent stops of line equipment during its implementation. In cases of using the second system, several tools are replaced at once, while the resource of some of them remains unexhausted completely. At the same time, the advantage compared to individual replacement is that with group replacement, the total number of stops, preparations for start-ups (including operations of checking the initial position of executive elements of machines, turning on the supply of fuel, lubricants, etc.) and line starts is reduced, and therefore, a certain amount of time was spent on one instrument.

The curves are built for the following conditions: the preparatory and final time is equal to the time of changing one tool (40 s), the minimum stability T = 90 workpieces, each tool next in terms of stability ensures processing of 10 workpieces more than the previous one. As can be seen from the graph, if the number of simultaneously used tools during processing on a machine or line is N = 1 ÷ 4, the time loss is small, regardless of the implementation of one or another replacement option. The more tools N are simultaneously running on the line, the more efficient is the application of group replacement. It is most profitable to replace 4-5 tools at the same time. This condition is valid only with stable and reliable operation of the tools. When operating automatic lines from aggregate machines, in a number of cases group replacement is rejected as less effective. The stability and reliability of the tools depends not only on their number, but also on the parameters of the processed workpieces, primarily on their hardness and geometric dimensions. For example, when drilling holes or cutting internal threads in workpieces made of non-ferrous alloys using high cutting speeds, the stability of the tool can change by 3-4 times depending on the hardness of the processed material.

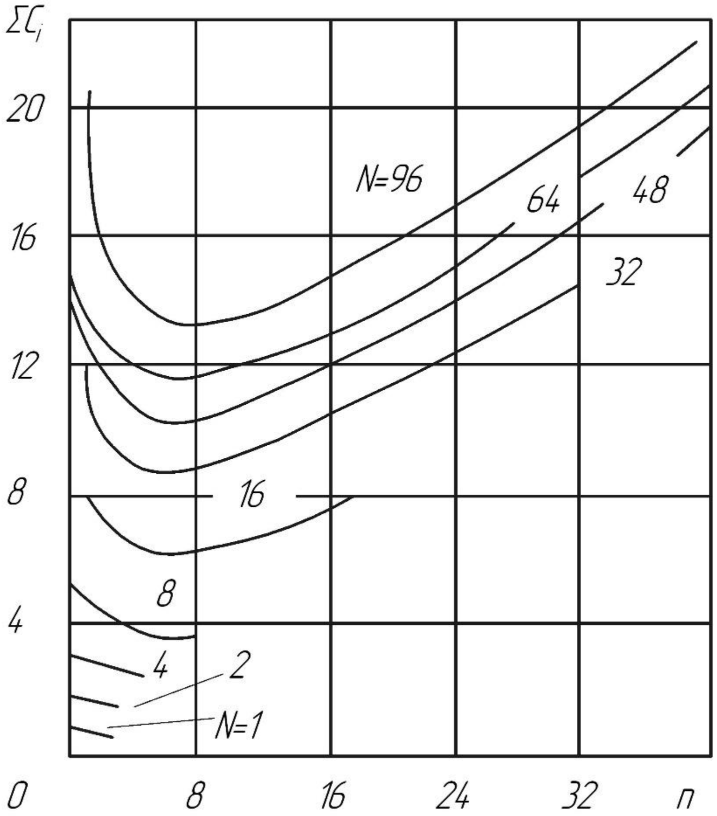

Figure 7 - Dependence of time losses ΣC_i on the number of simultaneously replaced tools

Before installation on the equipment of the line, the cutting tool, both new and re-turned, must undergo control, during which the geometric dimensions of its working part, sharpening angles and surface cleanliness are checked. For the tool of automatic lines, only centralized sharpening is permissible.

8.6. Basic rules for choosing and prescribing lubricants

for lubricating nodes and parts of automatic lines

The choice of the brand of working fluid for lubrication systems of the equipment of auto-matic lines is carried out according to the following rules.

1. The higher the specific load or operating temperature on the friction surfaces of mutually moving machine parts, the higher the viscosity of the working fluid should be.

2. The higher the speed of the relative movement of the friction surfaces, the lower the viscosity should be.

3. The solidification temperature of the working fluid should be lower than the minimum permissible temperature in the room, and the flash point should be higher than the maximum working temperature.

4. If the necessary lubricant is not available, it can be replaced with another of similar or slightly higher viscosity or a mixture of two lubricants of the required viscosity. Low-viscosity lubricant mixtures for lubrication of fast-acting mechanisms can be obtained from industrial oils by diluting them with high-acid kerosene. The final viscosity of the lubricant must be checked in the laboratory.

5. As a working fluid for hydraulic systems, only stable oils should be used, for which the temperature viscosity curves are the most gentle.

6. In all cases, water or emulsion should not get into the working fluid, since the presence of these foreign impurities leads to its emulsification and extrusion from lubricated units, destruction of the oil film, overheating and failure of mechanisms.

Plastic lubricants and ointments, used to lubricate parts and parts of machines, are thin colloidal mixtures (emulsions) of mineral oil in the amount of 75-95% with thickeners, which are used, for example, by salts of fatty acids. Depending on the composition of the soap, there are calcium-based, sodium-based, and calcium-sodium-based ointments.

Most often, solidols are used to fill oil pans and housings of ball and roller bearings, as well as to lubricate gear and chain gears.

The main characteristic of ointments is penetration, which determines the thickness of the lubrication. Penetration is measured using a special device - a penetrometer - depending on the depth of immersion in the lubricant under the influence of gravity of a measuring cone with an angle at the top of 90° and a mass of 150 g, for 5 s at a certain temperature. Penetration is equal to the immersion depth of the cone, expressed in tenths of a millimeter. The smaller the penetration, the thicker the ointment.

Another characteristic of the ointment is its drop temperature. The latter is determined using a device, the main element of which is a capsule mounted on a thermometer. During the test, the capsule is filled with the pre-monitored ointment.

Calcium lubricants (solidols US-2, US-3) have a low drop point. During melting, the moisture included in their composition evaporates and they lose their lubricating properties. However, these lubricants are quite stable in conditions of a humid atmosphere, even when a certain amount of water gets into them directly.

Sodium lubricants (konstalin UG-1, UG-2 and others) have a relatively high drop point and do not lose their lubricating properties when cooled after melting. The main disadvantage of these ointments is the high probability of decomposition when moisture gets into them.

Calcium-sodium lubricants (for example, UTV) are combined. They have a smooth non-fibrous structure, good stability and a high drop temperature.

Plastic lubricants are not used at high speeds of movement of friction pairs and elevated operating temperatures.

The costs of lubricants are normalized. The rate of consumption is understood as the minimum amount of lubricant, when using which minimum energy losses and the lowest operating temperature of the friction surfaces are ensured.

The rate of consumption does not take into account the amount of lubricant required for the initial filling of the tanks and reservoirs of the lubrication system.

Usually, the norms of lubricant consumption are calculated for the machine as a whole without breaking it down by nodes. At the same time, the costs of plastic lubricants make up about 3.5% of their total costs.

If necessary, it is possible to determine the amount of lubricant needed to ensure high-quality lubrication of individual parts. For this purpose, the norms of one-time consumption of lubricants are taken into account, for example, for lubrication of running screws, gear wheels, flat surfaces, sliding and rolling bearings, etc. In such cases, the necessary costs are calculated depending on the size of the part and its lubrication system.

8.7. Safety techniques during debugging and operation of assembly machines and automatic lines

Before starting the machine or the line, the adjuster and the operator must perform the following operations:

1. Inspect the machine (line) and make sure its (her) mechanisms are in good working order. Executive elements of all mechanisms must be in their original positions.

2. Put the workplace (places) in order. Inspect the main and debugging control panels, the floor, the grid, the stand and wipe them dry.

3. Check the serviceability of the control mechanisms, lubrication systems, the level of the working fluid and the pressure in the hydraulic systems.

4. Inspect the protective devices of the machine (lines).

5. Check the condition and reliability of fixing the cutting tool, device and workpiece.

6. Adjust the lighting in such a way that the light is directed to the work area.

7. Check the cooling system and the level of ZOR in its tank.

8. Check the presence and operability of devices for removal and collection of shavings; inspect the machine (line) again.

9. Perform a trial run of the machine (line) and check the operation of its (her) auto-locking and emergency stop buttons.

During the operation of the automatic line, the following requirements must be observed:

1. Periodically and timely collect shavings.

2. Assemble the processed parts in the proper order.

3. Maintain the given position of each tool, which it should occupy on the equipment of the line; replace a dull tool in time.

4. Monitor the correct installation of workpieces on the line, the reliability of their fixation, ensure the correct operation of the tool.

5. Do not leave the key in the chuck after changing the cutting tool.

6. Do not touch the rotating parts of the machines during their operation.

7. Turn on the machine (line) only after making sure that no one is in danger.

8. Use special devices to remove parts of the broken instrument from holders and mandrels.

9. When replacing the cartridge or the tool fixed in it, place a wooden block under the spindle.

10. When removing the cutting tool, chuck or adapter sleeve from the spindle, use a special key, a wedge and a hammer.

11. In the event of a tool breakdown, detection of a malfunction in the machine, transporter, device, loosening of fastening bolts, slats, gaskets, stop the machine (line) immediately.

12. During the operation of the line, it is necessary to periodically inspect it in order to ensure the normal operation of all mechanisms.

13. If it is necessary to adjust the equipment, the line should be stopped, the pneumatic and hydraulic systems should be turned off, and a sign with the inscription "Do not turn on" should be hung on the power supply switch. Debugging is in progress." If the electrical equipment of the line is under voltage during adjustment, then an electrician must be present near the start panel.

14. All personnel servicing the line must know the above safety rules and receive appropriate instructions for its operation.

Fire prevention measures.

A fire on the line can occur due to the ignition of kerosene, lubricants, cleaning material, paint, etc. Another common cause of fire is contamination of the machine (line).

When cleaning workplaces near the automatic line, cleaning materials must be placed in special metal boxes, and flammable objects and gas cylinders must be moved to places specially designated for their storage.

After completion of work on the line, all its equipment and electrical appliances should be turned off and only the bulbs of the regular lighting should be left on.

The local fire-fighting equipment of the line should be in a suitable place. Its condition should be periodically checked.

9. TYPES OF WEAR AND DEFECTS OF MACHINE PARTS AND ASSEMBLIES. DETECTION OF DEFECTS, REPAIR AND MODERNIZATION OF MACHINES

9.1. Wear and tear of machine parts and assemblies

The service life of the equipment is mainly determined by the rate of wear of its parts and the intensity of the loss of original functional and operational characteristics by the mechanisms. Wear is the process of destruction and separation of material from the surface of a solid body, an irreversible process of changing the shape, size and condition of the surfaces of machine parts during its operation. Depending on the working conditions, some parts wear out faster, while others wear out more slowly. The main types of wear are [14]: mechanical, seizing, and oxidative.

The first type of wear of the surface layer of the material of parts that work together is the result of mechanical influences, as a result of which there is abrasion and cutting of the contacting surfaces. The intensity of mechanical wear increases significantly in the presence of abrasive dust and foreign solid particles on the friction surfaces, which leads to the formation of scratches on them. In addition, the amount and nature of wear of parts depend on the physical and mechanical properties of the upper layers of the material from which they are made, the value of contact pressure, the relative speed of movement of the connected surfaces, their lubrication conditions, roughness parameters, etc. . In addition to wear caused by the relative movement of contacting parts, crumpling of their surface layers is possible, which is characteristic of slotted, keyed, threaded and other connections.

During the operation of machines, a number of their parts, including shafts, gears, connecting rods, bearings, springs, etc., are exposed to variable loads, which leads to a much more intense decrease in their strength than under the action of static loads . The impact of cyclic loads causes fatigue wear and destruction of parts with the formation of areas of cracks and fractures on their surfaces. The surface of the crack zone is smooth, and the surface of the fracture zone is granular or with shells. This appearance of worn tops indicates that the cause of the breakdown is fatigue. To prevent failure from fatigue, it is necessary to correctly choose the dimensions of the cross section of the connecting part, the shape of which should be, if possible, without sharp transitions from one section to another. It should also be taken into account that the presence of lines and scratches on the treated surface can also cause the appearance of fatigue cracks.

Wear during seizing occurs as a result of adhesion of one surface to another, as well as deep tearing of the material. Such wear is the cause of insufficient lubrication and significant specific pressure in the zone of close contact of two surfaces, as a result of which intermolecular forces begin to act on them. Seizure also occurs at high sliding speeds or in cases of significant pressure on the friction surfaces, as a result of which their temperature increases significantly.

Oxidative wear of parts' surfaces occurs when they are directly exposed to water, air, chemicals, and temperature fluctuations. Thus, an unacceptable increase in air temperature in the production room leads to the fact that the water vapor contained in it comes into contact with colder metal parts and is deposited on them in the form of condensate. The latter causes metal corrosion, that is, causes the beginning of the connection of the metal with the oxygen of the air and the destruction of the parts with their loss of mechanical strength. The described phenomena take place during the operation of parts of grinding, electrochemical and other machines working in contact with water-emulsion coolants. Due to the fact that the contact of a number of parts of this or that unit of the machine is direct, corrosive wear is usually accompanied by mechanical influence. In this case, the so-called corrosive-mechanical wear occurs.

The presence of noticeable wear of certain parts of the equipment can be judged by the change in the nature of their work. For example, increased noise in gears is a sign of wear of the profile of their teeth. Unacceptable wear of spline and key joints manifests itself in the form of sharp shocks when changing the direction of rotation or linear movement of the executive elements of the machine, which are set in motion with their help. The condition of assemblies with rolling bearings can also be assessed by the noise level. Diagnosis is carried out using a special device - a stethoscope. In its absence, you can use a metal rod, which is applied with a rounded end to the ear, and a pointed one - to the point of the surface of the node, which is closest to the bearing. During normal operation of the latter, only a weak noise, a uniform thin buzzing will be heard. A sharp ringing noise or whistling indicates that the bearing lacks grease or the rolling elements are too tightly squeezed between the raceways of the inner and outer rings. Intense noise (frequent ringing, knocking) indicates that there are shells on the balls, rollers or rings or abrasive dust or dirt has entered the bearing. Dull knocks indicate a loosening of the bearing in the housing or on the shaft.

The fact of significant wear and tear of the components of the machine can be established not only by hearing, but also by the appearance of the surfaces of the workpiece processed on it. For example, the presence of evenly spaced annular protrusions or depressions on the latter after turning processing indicates the wear of the teeth of the rack wheel and the rail of the longitudinal feed mechanism of the machine, as a result of which the movement of its caliper becomes more intermittent. This processing defect is also often caused by wear of the guide surfaces of the bed and the caliper carriage, which leads to a violation of the alignment of the holes in the apron and the transmission box for installing the running shaft; in addition, the clearance in the rack gear is inadmissibly changed.

An increase in the value of the "dead" movement of the handles of the longitudinal or transverse feed of the caliper or the machine table indicates the wear of the thread of the corresponding screws and nuts. In this case, dead travel is understood as a certain angle, when turning the control handle, the movement of the executive element of the machine associated with it does not occur.

It is recommended to use the method of "artificial bases" to estimate the value of the wear of the friction surfaces of the basic parts of the equipment. When implementing the method, holes of a certain shape are pressed in advance on the surfaces that will be subject to wear (Fig. 11.1). They practically do not affect the change in the friction mode, due to their relatively small size: depth 50-75 microns, length 1.7-2 mm, distance between adjacent holes 100-200 mm. Holes are made using a diamond pyramid (impression method) or using a rotating hard alloy roller ("wiping" method). The second method is more perfect, because when it is implemented on the sides of the hole, the metal does not swell, which allows for more accurate measurements. The value of wear is judged by the amount of reduction in the depth of the hole during a certain time of machine operation. The depth of the hole is determined by the formula

$$h = L^2/8 \cdot r,$$

where L is the length of the hole;

r is the radius of curvature of the recess.

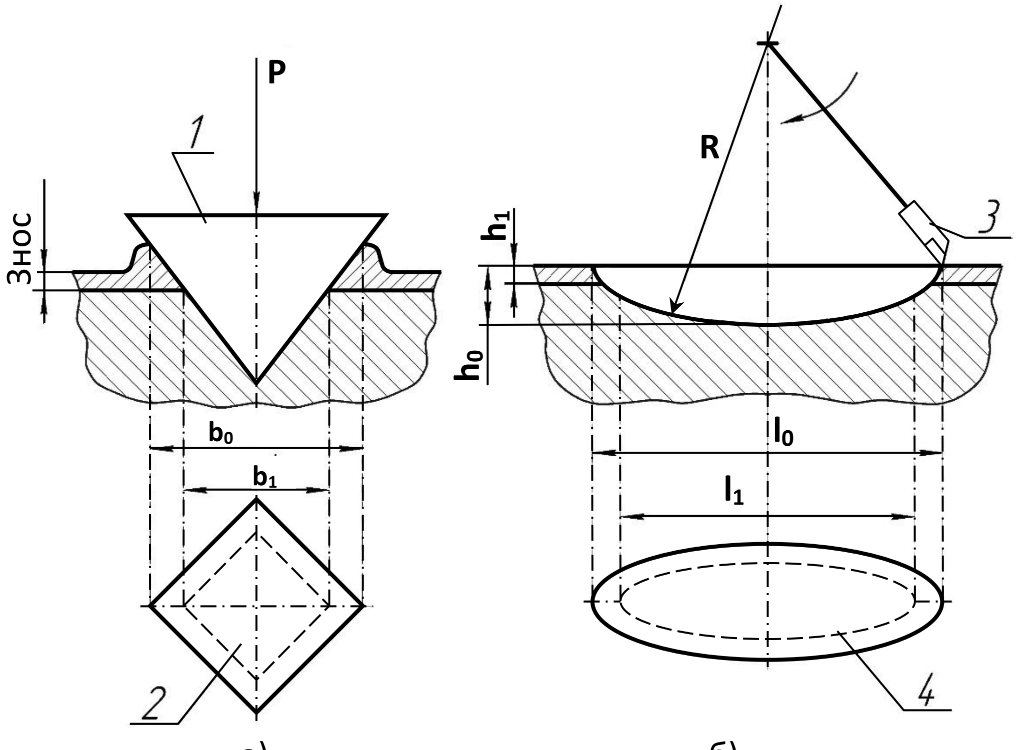

Figure 8 - Schemes of making an impression (a) and holes (b) for determining the amount of wear of the guides: 1 – diamond pyramid; 2 – print; 3 – incisor; 4 – hole

In the case of using the method of "wiping" the holes, it can be done using the PVL-2 device (Fig. 8). The device is connected to the lighting network of the machine and installed on the wearing surface of its base part in such a way that the roller 1, fixed on the mandrel 2, contacts the area where the hole needs to be made. With the help of the switch 9, the illuminator lamp 7 and the electromagnet 8 are turned on, which ensures a rigid fixation of the position of the device on the base surface. Then two or three drops of oxidizing agent (1% solution of K2CrO4 in water) are applied to the latter; turn on the electric motor 3, the shaft of which is connected to the mandrel 2. By turning the handle 6, the roller 1 is brought closer to the base surface, ensuring "wiping" of the hole on it.

The length L of the wells is measured using the MIB-2 device, which is a counting microscope with a micrometric screw.

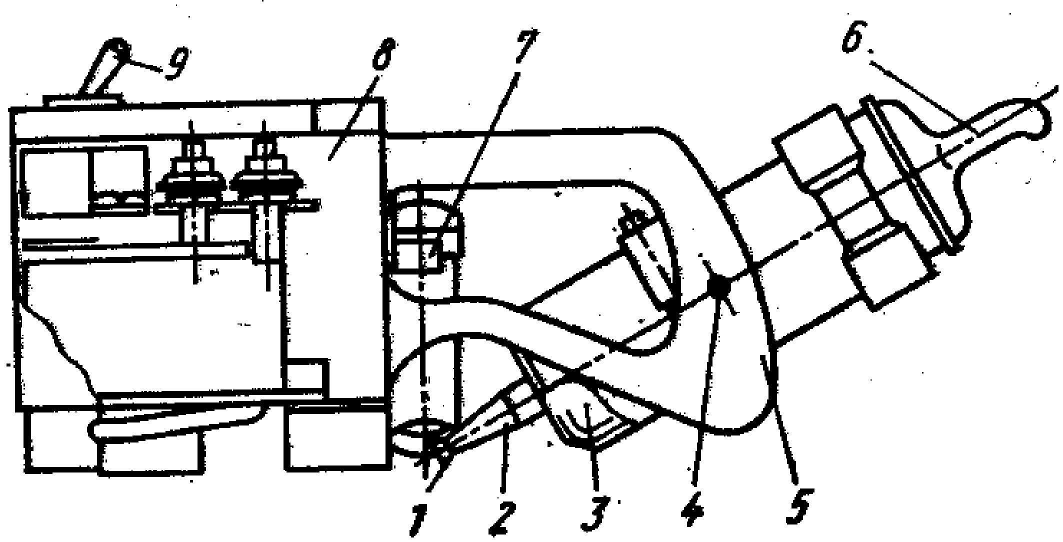

Fig. 11.2. Device for making holes on the surfaces of guide machines: 1 – roller; 2 – mandrel; 3 – electric motor; 4 – axis; 5 – bracket; 6 – handle; 7 – illuminator; 8 – electromagnet; 9 - switch

Holes are made on the surfaces of guide machines closer to their middle and in a direction perpendicular to the direction of movement along the guide executive elements. The latter ensures the preservation of the clarity of the edges of the holes during wear.

The permissible amount of wear of the guide frames of lathe-screw-cutting and drilling-milling machines is standardized depending on the specified accuracy and the dimensions of the workpieces processed on them. If the wear of the guides exceeds 0.2 mm, the vibration resistance of the equipment is significantly reduced, and although, according to the conditions for ensuring the specified accuracy of workpiece processing, it is possible to continue its use, it is necessary to stop the machine for major repairs due to the deterioration of the quality of the processed surfaces (the formation of traces on them caused by intense vibrations of executive elements during work) or due to a decrease in productivity.

The permissible amount of wear of guide longitudinal planing and longitudinal milling machines can be determined by the formula

$$U_{max} = \delta(L_0/L_1)^2,$$

where δ is the error of processing on the machine (tolerance for the appropriate size of the part), mm;

L0 – length of bed guides, mm;

L1 – the length of the processed workpiece, mm.

For flat guides, the wear value is equal to the vertical distance from some conventional straight line passing through the points on the unworn ends of the guides to the worn surface. For machines with V-shaped or triangular cross-section guides with a base angle α, the allowable amount of wear is calculated as

$$U_{max} = \delta \cos\alpha \, (L_0/L_1)^2.$$

In the operation of automatic lines, which include a large number of controlled equipment, access to the friction surfaces of which is limited for the purpose of assessing their wear, along with the method of "artificial bases", the method of surface activation is used. In the case of implementation of the latter, the working areas of the surfaces of guide machines, spindle assemblies, gears, screw and worm gears, and other responsible mechanisms are subjected to surface activation in cyclotrons by a beam of accelerated charged particles (protons, neutrons, alpha particles). The depth of the activated layer should correspond to the expected amount of linear wear of the part. To control large-sized parts, special pre-activated inserts are used. The amount of wear of activated surfaces is judged by periodically measuring the radiation energy.

One of the main measures to reduce the intensity of wear of machine parts is the lubrication of friction surfaces, which as a result are separated by a layer of lubricant and thus small irregularities (roughness) on them do not contact each other. The implementation of circulating lubrication contributes to better heat removal, removal of foreign particles and wear products from the contact zone, as well as protection of parts from corrosion, than the periodic manual application of lubricant.

9.2 Defect detection methods and restoration of machine parts

Types of defects and methods of their detection.

Defects arising during the operation of the equipment can be divided into three groups: wear and tear, which includes scratches, lines, burrs; mechanical damage (cracks, broken teeth, breaks, bends and twisting), chemical and thermal damage (cracking, pitting, corrosion).

Most of the large and medium-sized mechanical defects are detected during an external inspection. In some cases, the check is carried out with the help of a hammer. A rattling sound when tapping the part with a hammer indicates the presence of significant cracks in it.

Various flaw detection methods can be used to detect small cracks. The simplest are capillary methods. If, for example, the part is immersed in kerosene for 15-30 minutes, if there are cracks, the liquid will penetrate them. After thorough wiping, the surfaces of the parts are covered with a thin layer of chalk, which absorbs kerosene from the cracks, as a result of which dark stripes appear on the surface, indicating the location of defects. Liquids that glow when irradiated with ultraviolet rays (capillary luminescence method) are used to more accurately determine the location of cracks. Such a liquid is, for example, a mixture consisting of 5 parts of kerosene, 2.5 parts of transformer oil and 2.5 parts of gasoline. The part is immersed in this mixture for 10-15 minutes, then washed and dried, after which it is irradiated with ultraviolet rays (mercury-quartz lamp). A light green glow appears in places of cracks.

In addition, the presence of cracks in the parts can be detected using methods of magnetic flaw detection. The part is magnetized and then moistened with a magnetic suspension (iron oxide powder mixed in oil, kerosene, or a water-soap solution). Accumulations of powder will form in places of cracks (Fig. 10.3, a). Longitudinal cracks are detected when magnetic lines pass around the part (Fig. 10.3, b), and transverse cracks - during longitudinal magnetization, when magnetic lines pass along the axis of the part (Fig. 10, c).

Defects located inside the material of the part are detected using the fluoroscopic method. At the same time, X-rays passing through the controlled part fall on a sensitive film, on which defect-free volumes are displayed as darker spots, and dense extraneous

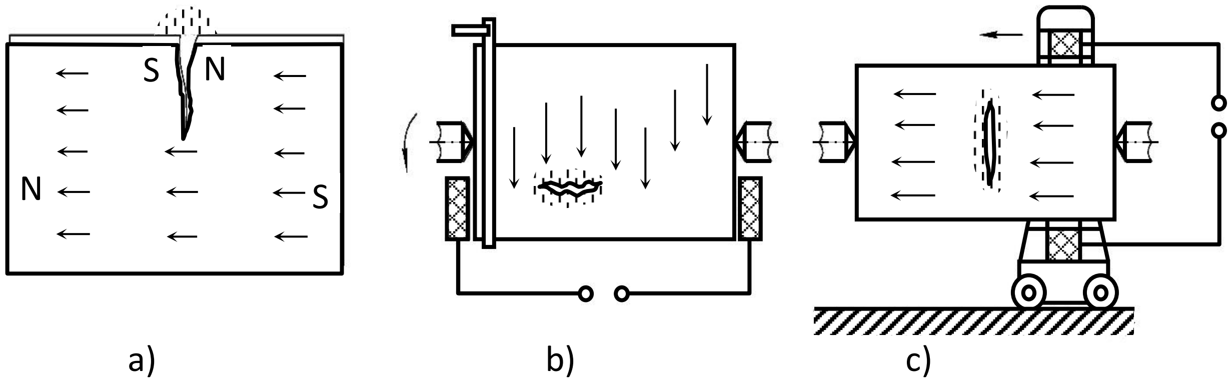

Figure 10 - Schemes of conducting magnetic defectoscopy: a – accumulation of magnetic powder near the crack; b – rotational magnetization; c – longitudinal magnetization

inclusions - as lighter spots.

Nowadays, the ultrasonic method of detecting cracks and other hidden defects has also gained some popularity. When it is implemented, an ultrasonic probe is attached to the investigated part, the main part of which is a crystal generator of high-frequency mechanical vibrations (0.5-10 MHz). These vibrations, passing through the material of the part, are reflected from its internal free surfaces (cracks, fracture surfaces, shells, etc.) and fall back into the probe. The device registers the delay time of the reflected waves relative to the emitted ones. The greater the given time, the greater the depth at which the defect is located. For a better transmission of vibrations to the part under investigation, the latter is usually placed in a liquid (water, oil, etc.).

Multiple use of worn machine parts can be ensured by implementing such methods as restoring the original dimensions, transferring them to another size group, as well as the method of compensators.

Methods of restoration of machine parts and mechanisms.

Restoration of equipment parts and mechanisms is carried out with the help of several basic methods.

Machining by cutting or the method of repair dimensions is used to restore the accuracy of guide machines, worn holes or necks of shafts, threads of lead screws and in other similar cases. As a rule, the more expensive, labor-intensive and metal-intensive part of two connecting parts is repaired, and the cheaper part is replaced. In the case of significant wear of the executive surfaces, the parts after the necessary restoration (turning, planing or grinding) are transferred to the next group, depending on the size of the repair dimensions.

The repair size is the size to which the worn surface is processed during the restoration of the part. There are free and regulated repair sizes. Free sizes are called the dimensions, the value of which is not established in advance, but is determined and ensured directly in the processing process, after removing signs of wear and restoring the original shape of the detail. According to the values of the obtained size, the specified gap or tension in the connection and using the method of individual fitting, the processing of the paired part is carried out. At the same time, it is impossible to perform the final processing of spare parts before the start of the appropriate repair fitting operation, which is a disadvantage of the system of free repair sizes. The regulated repair size is a predetermined size to which the worn surface is treated during its restoration. At the same time, spare parts can be manufactured in advance, there are conditions for applying the interchangeability method during repair, as well as for speeding up the recovery process. The main starting data when calculating the regulated repair sizes are the amount of wear during the inter-repair period, as well as the processing allowance. The final value of the repair size is established based on the conditions of strength and durability, as well as taking into account the design features of the connected parts.

When repairing guide machines, the broken dimensional chain connecting their surfaces with the surfaces of caliper carriages or other assembly units is restored by fixing the compensating parts on the guides.

Parts with fractures, cracks, and chips are restored using the welding method. The surfacing method is a type of welding, which consists in the fact that an additive material is superimposed on the worn area. The use of metals that are more wearresistant than the main material of the part to be repaired, as well as hard alloys for surfacing, makes it possible to carry out its repair many times and significantly increase its service life. However, when restoring machine elements by welding and surfacing, it is necessary to take into account the possibility of deformations (boxing) in them, as well as internal stresses caused by uneven heating.

When repairing steel parts, arc welding with metal electrodes is quite often used. The weldability of steel depends on its chemical composition, that is, the content of carbon and alloying elements, such as chromium, manganese, nickel and others. As the number and specific mass of the latter increase, the weldability deteriorates. Steels with a lower content of carbon and alloying elements can be deposited or welded under normal production conditions without preheating and without further heat treatment. Parts made of steel with limited or poor weldability may crack in the welding zone, therefore it is recommended to pre-anneal them at a temperature of 500-600 °C, and after the welding is completed, subject to hardening and tempering.

When restoring parts made of cast iron, as well as carbon steel up to 3 mm thick, gas welding in an oxygen-acetylene flame with a certain excess of acetylene (the so-called restoration flame) is used. At the same time, cast iron additive material in the form of rods with a high content of carbon and silicon is also used (the specified elements partially burn out during the welding process). Fluxes are used to prevent oxidation of the molten material, and in addition, if there are suitable conditions, the welding process is carried out in an inert gas environment.

Parts from gray cast iron can be welded with preliminary general heating, with local heating or without them. Welding with preliminary heating up to 500-700 °C is conventionally called hot, with heating up to 250-450 °C - semi-hot, and without heating - cold. Hot welding gives the best results. The method of restoring cast iron parts using welding and soldering with brass wire and rods made of copper-zinc tin alloys has also become quite widespread. When implementing this method, the welded edges are heated only to the melting temperature of the solder.

Malleable cast iron does not lend itself well to welding by conventional methods, so parts from it are restored using brass electrodes or electrodes made of monel metal, that is, an alloy of nickel with copper, iron and manganese. Monel metal has high corrosion resistance and mechanical strength.

In order to perform high-quality welding, appropriate preparation of the surfaces to be welded is necessary, as well as the implementation of the given mode of their cooling. Large parts are cooled together with the furnace, small ones are placed in dry hot sand or ash, because rapid cooling leads to the formation of hard and brittle bleached iron. Uneven cooling contributes to the emergence of internal stresses and the appearance of cracks in welded parts.

The essence of the metallization method, which is also used for the restoration of machine parts, consists in melting the metal and spraying it with a jet of compressed air into small particles that are introduced into the unevenness of the worn surface and adhere to it. Metallization can be applied to parts made of different materials that work under a uniform and relatively small load. Since there is no heating of the metallized part, the possibility of any internal stresses and distortions in it is completely eliminated. Using the metallization method, a layer of metal with a thickness of 0.03 to 10 mm or more can be built up.

Metallization installations can be gas (the metal in them melts in the flame of a gas burner) and arc. The scheme of the arc metallizer is shown in fig. 11.4. Two coils with wires 3 fed by two pairs of rollers 5, which rotate slowly, are installed in its body. Electric current is supplied to the wires through wires 6. In the area where the wires converge, an electric arc occurs, when heated, the metal of the wires melts and, under the influence of a stream of compressed air coming through pipe 4, is thrown onto part

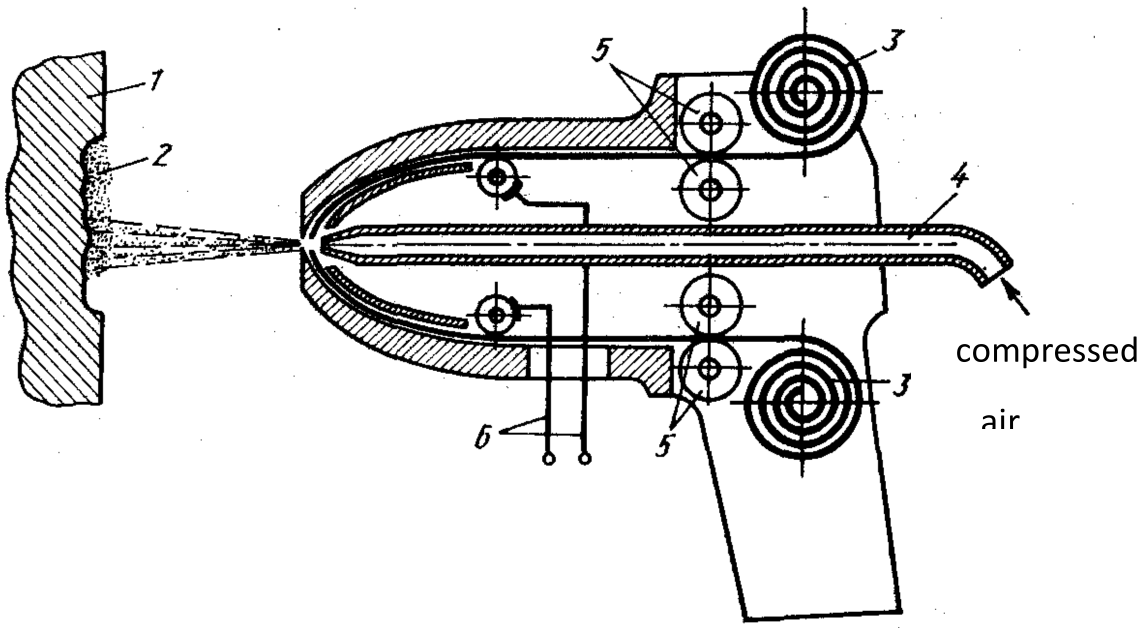

Figure 11 - Scheme of the arc metallizer

The surface that will be subjected to metallization must be degreased beforehand; it must be sufficiently rough, which is ensured by its sandblasting, incising on it with the help of a gouge tooth, cutting a small thread (on parts of a round cross-section) and when using other methods. The built-up layer 2 is porous, the strength of its bond with the base metal is sufficient for cutting, but insufficient for resistance to dynamic and shock loads. Ensuring a sufficiently high porosity of the built-up layer helps to increase the wear resistance of the metallized surface due to better retention of the lubricant on it and a reduction in the coefficient of friction.

Chromium plating is another method of restoration of worn surfaces of parts, in the implementation of which chromium is deposited electrolytically on these surfaces. Chrome-plated surfaces have increased hardness and wear resistance, but do not resist the influence of dynamic loads. Chromium plating is a less universal method than metallization, because when using it, the built-up layer of chrome has a relatively small (up to 0.1 mm) thickness (when the thickness of the layer increases, its quality deteriorates), in addition, sufficient uniformity and quality are not ensured -covering the surfaces of parts of a complex configuration. At the same time, the considered method has a number of undeniable advantages over other methods of restoring details.

Thus, the built-up layer of chrome after partial wear can be easily removed by electroplating (dechroming), and, thus, it is possible to repeatedly restore parts without changing their dimensions. Further, the use of dimensional chrome plating allows to simplify the entire processing process by reducing the final grinding operation. And, finally, the chrome plating process takes place at low temperatures, due to which the structure of the base metal is not disturbed.

Chrome plating is also successfully used in the restoration of large-sized parts that cannot be placed in chrome plating baths or contain surfaces of such a large area that it is necessary to provide a very strong electric current to apply a coating on them. In such cases, the use of portable baths that directly cover the chrome-plated surfaces of the part (Fig. 11.5), or the implementation of successive chrome-plating of the surfaces by separate belts of large areas allow to successfully solve the above-described problems.

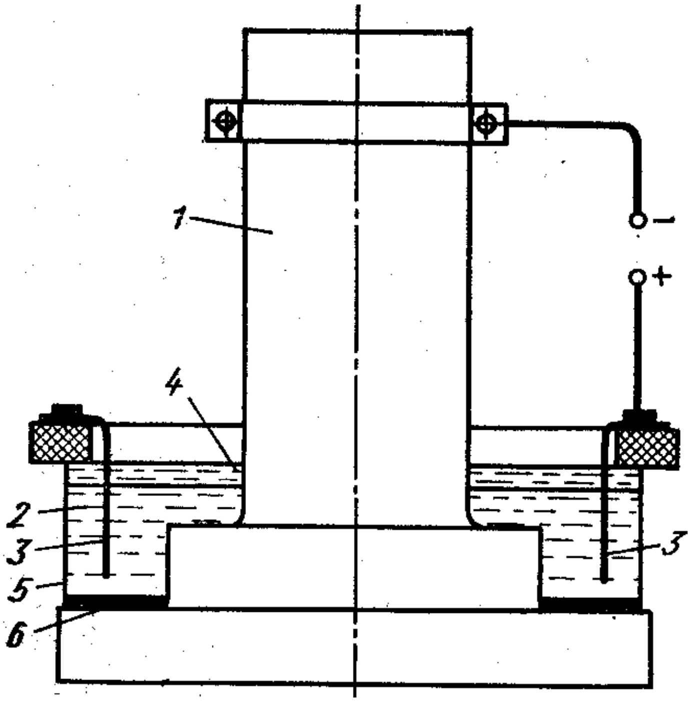

Figure 12 - Chromium plating of large-sized parts using portable baths: 1 – renewable part; 2 – electrolyte; 3 – lead anodes; 4 – protective liquid; 5 – celluloid; 6 - glue

11.3. Methods of repairing machines

Before disassembling the repaired machine, it is necessary to check it for geometric accuracy and record all detected deviations. Disassembly is carried out by nodes. If there is no kinematic diagram of the equipment, it is developed in the process of disassembly, in addition, a list of detected defects is compiled in parallel [6].

Details whose position in the assembly must be strictly defined (cams, couplings, hydraulic distributors, etc.) must be marked. For this, an electrograph, shock or acid stamp is used.

Pins with a threaded end are removed after screwing the nuts on them, pins with a threaded hole are knocked out with the help of a special impact device (Fig. 12, a). The landings with tension are disassembled using a press or a puller. In addition, hammers with copper hammers or copper rods are used for disassembly. To facilitate disassembly, the part to be installed is sometimes heated, for example in hot oil. For the same purpose, it is advisable to immerse the connected parts in kerosene for 8-10 hours. When disassembling the bearing, the pulling force is applied directly to the tension ring or to the part located behind the bearing (Fig. 12, b).

After disassembly, the parts are washed in kerosene or gasoline, and then wiped dry. To save kerosene, only the upper part of the washing tub is filled with it (the lower part is filled with water). The dirt that remains in the bath after washing is removed together with the water, and the kerosene is less contaminated. Hot washing of machine parts in baths with a steam anti-corrosion solution is more effective and fire-safe.

Let's consider some basic methods of repairing machine parts.

A broken shaft (Fig. 12, a) can be restored by pressing a new part onto the old one with installation in a transverse through hole passing through both parts of the pin (Fig. 12, b), or by welding with subsequent turning of the weld (Fig. 12 , c).

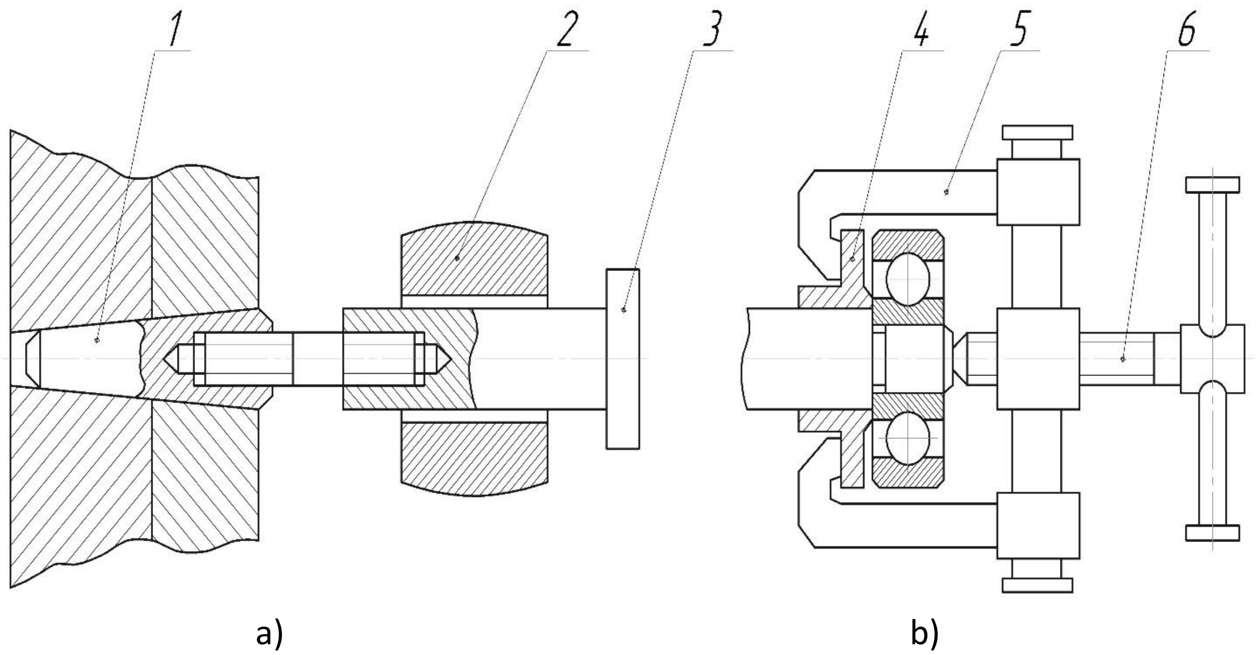

Figure 12 - Removers: a – for dismantling threaded pins; b – for dismantling bearings, rings, bushings; 1 – pin; 2 – cargo; 3 – emphasis; 4 - detail, located behind the bearing (sleeve); 5 – clamp; 6 – screw

The worn thread in the body part (Fig. 12, d) is drilled and reamed, and a sleeve with a new internal pre-cut thread is pressed into the resulting hole. If necessary, the pressed sleeve is additionally fixed with a stopper-screw (Fig. 13, e). Using the described method, parts with smooth holes are also repaired.

The exact fit on the sides of a worn splined shaft (Fig. 13, e) can be restored if, after annealing the shaft, the splines are expanded with core blows, and then the sides are hardened and polished.

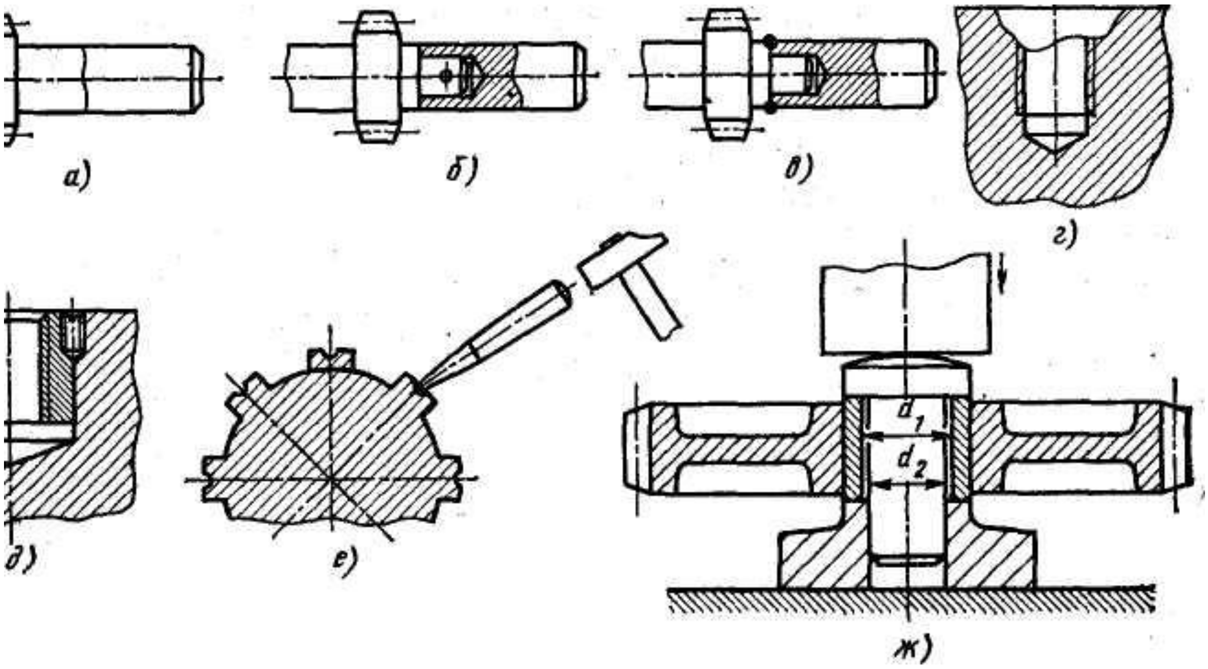

Figure 13 - Schemes of implementation of various methods of restoration of parts

The inner diameter of the bronze sleeve (Fig. 13, g) can be reduced from d1 to d2 by depositing it on a press. At the same time, the height of the sleeve does not change.

In the general case, the use of one or another repair method is dictated by the technical requirements for the part and economic feasibility, depends on the specific conditions at the production site, the availability of the necessary equipment, and the established repair deadlines.

The final stages of repair of metal-cutting equipment are its assembly, adjustment and testing. First, separate components and mechanisms of the machine are assembled, then they are mounted on the base, while the most rational is the method of parallel execution of assembly work with the involvement of a team of qualified locksmiths, which allows you to significantly reduce the downtime of the equipment during repair. For example, it is advisable to start the general assembly of a lathe with the installation of a caliper carriage on restored bed guides. After fixing the pressure bars on it, check and ensure the necessary smoothness of the movement of the carriage along the guides. At the same time, the front headstock, gearbox, apron, propeller and shaft are mounted. The front headstock must be installed in such a way that the axis of the spindle is parallel to the guides of the bed. Compliance with this requirement is monitored using a sample mandrel inserted into the spindle hole and an indicator fixed on the caliper. When moving the caliper, observe the deviations of the indicator arrow. Inspection is carried out in vertical and horizontal planes. If the actual deviations exceed the permissible ones, the support surfaces are sanded. In addition, the alignment of the axes of the propeller and the holes through which it passes are checked. Inadmissible deviations from joint overhang are eliminated by installing and fixing compensator overlays on the straight surfaces of the carriage or by grinding the contacting surfaces. Similarly, the set position of the drive shaft is ensured.

After installing and checking the specified components, the electric motor of the main drive is mounted and the belt transmission connecting it to the gearbox is adjusted. Next, the engine of quick movements of the caliper is installed, grease is poured into the reservoirs of the gearbox, covers are fixed, etc. After completing these stages, you can turn on the machine and carry out its preliminary running-in. The purpose of the latter is to identify possible assembly defects and to ensure that the friction surfaces of mutually moving parts are worked in.

Running-in is first carried out at idle and at the lowest speeds, while controlling the supply of lubricant to the friction surfaces. Simultaneously check the operation of all blocking devices. Next, all operating speeds are turned on alternately up to the highest. At maximum speed, the equipment should work for at least 1 hour without a break. In a similar way, the operation of the feed drive mechanisms is checked. During the running-in process, the heating temperature of the drive bearings is controlled, which for machines should not exceed the air temperature in the workshop by more than 40-50 °C. At the same time, all mechanisms must work smoothly, without jolts and vibrations. Robotic and electrical equipment should also be faultless. Even the smallest malfunctions are not allowed.

Under load, metal cutting machines will be tested by processing sample parts on them using different cutting speeds in accordance with the technical data of the equipment passport. Tests are carried out with the load of the machine up to the nominal power of the drive, with a gradual increase in the depth of cutting and feed.

Short-term overloading of the machine is also allowed, but not more than 25% of the nominal capacity. All mechanisms of the machine under load must work properly and reliably.

Next, they check the geometric accuracy of the machine and the roughness of the surfaces of the sample part processed on it, when reproducing the specified cutting modes. There should be no lines or scratches on these surfaces, and the accuracy of the dimensions of the standard should correspond to the technical data indicated in the passport of the machine.

Acceptance of machines after overhaul is carried out according to the same accuracy standards established for new equipment of a similar model. In addition to accuracy checks, the machine undergoes rigidity tests. For this purpose, its spindle and support are loaded using a dynamometer with a certain regulated force and measured using deformation indicators of these executive elements [6]. If the actual stiffness indicators of the machine do not match the specified ones, the gap in its bearings is adjusted, bolts, nails, slats and other fastening parts are tightened. At the same time, it is impossible to allow the bearings to be dragged, which often leads to their overheating during operation, violation of the smoothness of movement of the executive elements of the machine and an unacceptable increase in the working forces on them.

9.4 Modernization of machines

During the overhaul, it is desirable to modernize the equipment taking into account the conditions of its operation and using the latest achievements of science and technology. Modernization of machines is understood as the introduction of partial changes and improvements in their design in order to raise the technical level of the equipment to the level of modern models of similar purpose (general technical modernization) or to solve certain technological problems of production by adapting the existing equipment to specific conditions of its operation (performance of certain operations for the manufacture of original parts, implementation of specified cutting modes), as well as for improving the quality of products produced with the help of this machine (technological modernization). As a result of modernization, as a rule, the productivity of the equipment should increase, operating costs should decrease, the share of defective products should decrease, and in some cases, the duration of the repair period should increase. The diagram shown in fig. 13.

Modernization with the aim of reducing machine operation time of the equipment is carried out by improving its technical characteristics: increasing the power of the drive, expanding the range of values of cutting speeds and feeds. The latter should be accompanied by an increase in the rigidity and vibration resistance of individual machine nodes, the rigidity of fixing the instrument on them, etc.

Modernization to reduce auxiliary time is carried out by equipping the machine with various clamping and loading and unloading devices, devices for active control of dimensions during processing, software control.

Improvements in the accuracy characteristics of modernized machine tools are achieved due to an increase in their kinematic accuracy (improvement of reference devices, correction devices), geometric accuracy (improvement of spindle support structures, installation of precision bearings, increase of rigidity of nodes, etc.), reduction of temperature deformations (application of circulation lubrication, temperature compensators, etc.).

At the same time, it is expedient to modernize the equipment only if it is economically efficient. Premature modernization, as well as late, leads to production losses.

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