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Ternopil Ivan Puluj National Technical University
(full name of higher education institution)
Faculty of Engineering of Machines, Structures and Technologies
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Engineering Technology
(full name of department)

QUALIFYING PAPER

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Faculty Faculty of Engineering of Machines, Structures and Technologies

Department Engineering Technology
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APPROVED BY

Head of Department Okipniy I.B

ASSIGNMENT
for QUALIFYING PAPER

Mahmoud Mustafa
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1. Project (thesis) theme. Development of the body structure 20508.12.01. production production process and the study of cutting modes at turning

Project (thesis) supervisor PhD Pankiv V.R.
(surname, name, patronymic, scientific degree, academic rank)

1.Approved by university order as of 26.03. 2021 року № 4/7-222
2. Student's project (thesis) submission deadline
3. Project (thesis) design basis 1. Basic TP manufacturing parts. 2. The program is 70000 pieces/ year. 3. Drawing the body parts.

4. Contents of engineering analysis (list of issues to be developed)
1. Analytical part, 2 Research part 3.Technological part.4.Designing part.
5.Safety measures. 6.Drawing.

5. List of graphic material (with exact number of required drawings, slides)
Technological cards adjustments, assembly drawings of devices, drawing of the control device, schemes to the scientific part

6. Advisors of design (thesis) chapters

Chapter	Advisor’s surname, initials and position	Signature, date	
		assignment was given by	assignment was received by
Safety measures	*PhD. Prof Baranovsky V.*		
	Klepchik V.		

7. Date of receiving the assignment *29 March 2021*

PROJECT TIME SCHEDULE

LN	Diploma project (thesis) stages	Project (thesis) stages deadlines	Notes
1	*Analytical part,*	1.04.2021	
2	*Research part*	15.04.2021	
2	*Technological part*	1.05. 2021	
3	*Designing part*	15.05.2021	
6	*Safety measures*	1.06.2021	
7	*Drawings*	15.06.2021	

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Project (thesis) supervisor ____________ (signature) *Pankiv V.R.* (surname and initials)

ABSTRACT

Actuality of theme. The optimal parameters of the cutting mode are those values of the cutting speed and feed, at which the machining process would be most efficient in terms of economy and productivity, and would meet all the technological requirements for the workpiece. The need for automated calculation of optimal values of cutting mode parameters was pointed out in the middle of the last century, but this problem is still not solved and its relevance continues to increase with the development of multi-machine maintenance and the creation of automated machine tools for cutting metals.

The purpose of the study is to improve the manufacturing process of the body part 20508.12.01. with the study of cutting modes during turning

The object of study - the technological process of manufacturing the case 20508.12.01.

The subject of research - technological parameters of the turning process.

Research methods. The work is performed using the basic principles of computer technology and modeling elements

Scientific novelty: The influence of technological parameters of turning on quality of the processed surfaces is analyzed.

Practical significance. The improved technology of manufacturing of the case 20508.12.01 is offered. and the effect of the turning process on the quality of the treated surfaces was investigated.

Approbation of the results of the master's qualification work. Material of the IV International student scientific and technical conference NATURAL AND HUMANITIES. CURRENT ISSUES April 28-29, 2021p.

The structure and scope of the master's qualification work. The work consists of an introduction, four sections, a list of used sources and appendices. The full volume of the master's qualification work is 59 pages, including 20 figures, 10 tables, bibliographies from 5 sources to two pages.

	CONTENT	

INTRODUCTION

Nowadays, milling has become one of the most commonly used methods for obtaining surfaces by cutting, since the latest trends in the field of mechanical engineering are the combination of several types of processing in one operation, one of which is often milling. This is evidenced by the creation of modular and multi-purpose, as well as five coordinate milling machines.

The main advantages of this processing method are high productivity, accuracy and quality of the processed surfaces. However, the main feature of the process, which limits the scope of its application, is its dynamic imbalance, which is caused by a constant change in the cut thickness, and, accordingly, a change in the cutting force. This work is devoted to the study of the laws of change in the cut thickness and the influence of this phenomenon on the stability of the cutting process during milling.

When designing technological processes for the manufacture of machine parts, it is necessary to take into account the main directions in modern engineering technology:

Approximation of workpieces in shape, size and surface quality to finished parts, which makes it possible to reduce material consumption, significantly reduce the labor intensity of processing parts on metal-cutting machines, as well as reduce the cost of cutting tools, electricity, etc.

Increase in labor productivity through the use of: automatic lines, automatic machines, modular machine tools, CNC machines, more advanced processing methods, new grades of materials for cutting tools.

Concentration of several different operations on one machine for simultaneous or sequential machining of a large number of tools with high cutting data.

1. ANALYTICAL PART

1.1 Analysis of the state of the issue according to literary and other sources. Relevance of the topic of work

Experience of operation of machines, devices convincingly shows that their reliability is determined by the condition of the surface layer of parts and depends on the nature of their contact with each other or with liquid, gaseous and other media, [1]. According to the results of many studies performed primarily by scientists D.D. Papshev, I.V. Kudryavtsev, Yu.G. Schneider, L.O. Hvorostukhin, Y.I. Babeyom, B.I. Kostecki, P.I. Yashcheritsyn, P.A. Chepa and others found that surface quality indicators significantly determine the wear resistance, strength, corrosion resistance and other performance properties of machine parts. The modern development of mechanical engineering is associated with the creation and development of technology for processing workpieces from steels and alloys with high physical and mechanical properties - high strength, corrosion resistance at elevated temperatures in different environments. The dominant methods of processing metals with special physical and mechanical properties are traditional cutting methods, and attempts to replace them with electrophysical, electrochemical methods have not had significant success due to significant material and energy costs and the complexity of the technological equipment used.

In the theory of cutting are considered: the general laws of process of formation of shaving; forces acting on the tool and their influence on the cutting process; thermal phenomena that occur during cutting; operation of tools and ways to increase their stability. The influence of tool geometry on the cutting process; influence of cutting modes on cutting forces and tool stability; rules for choosing a coolant and how to bring it to the cutting zone.

The essence of metal cutting is to cut the surface layer of metal (allowance) from the workpiece in the form of chips to obtain a part of the desired shape, size and with the appropriate surface quality. Studies have shown that the process of cutting metal is, in essence, chipping and shifting of metal particles under the action of the force with which the front surface of the cutter is pressed into the cut layer (Fig. 2.1). Chipping of metal particles (chip elements) occurs in the plane of chipping $\tau - \tau$, placed at an angle of chipping β1 = 30...40° to the treated surface. Inside each element there are between crystal shifts at an angle (β2 = 60...65°).

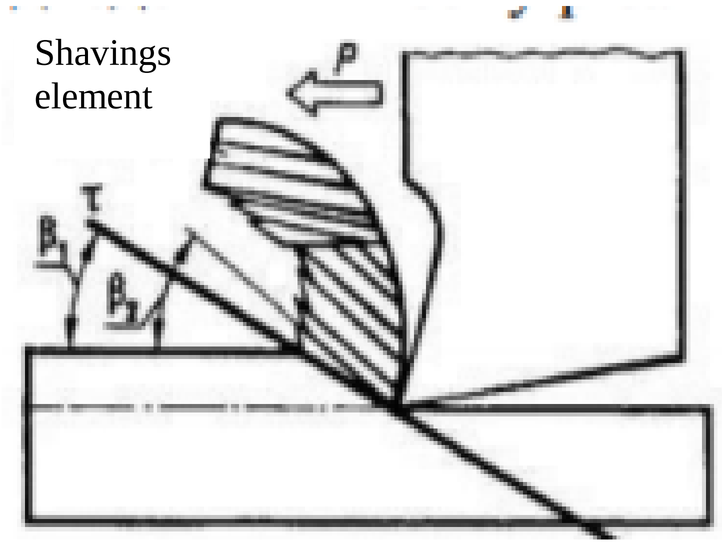

Figure 1.1 - Shaving chip scheme

Depending on the processed metal and cutting conditions, chips of different types are formed (Fig. 1.2): stepped, chipped, drained spiral, drained tangled. The formation of fracture chips is characteristic of the processing of cast iron and bronze.

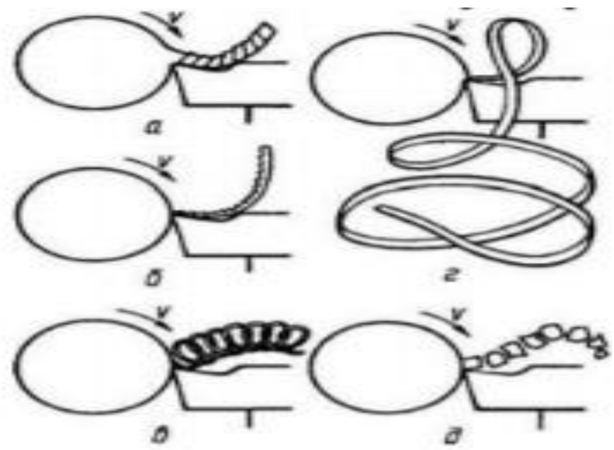

Figure 1.2 -Types of shavings: a - stepped; b - chipping; c - drain spiral; d - drain tangled; e - breakage (bulk)

Each chip element is compressed by the force applied from the front surface of the cutter. As a result, the length of the chips is always less than the length of the surface from which it is cut (Fig. 1.3). This phenomenon is called chip shrinkage and is characterized by a shrinkage factor $K = \frac{L}{L0}$, де L_0 - length of the processed surface (a way of passage of the cutter on preparation), mm; L — chip length, mm.

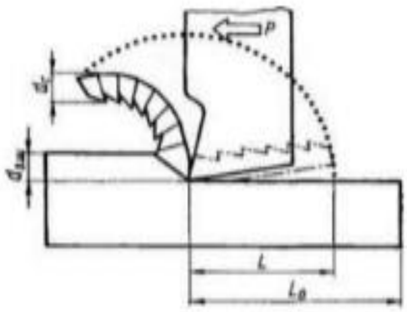

Figure 1.3 - Chip shrinkage scheme:

d_c - chip thickness; $d_{з.ш}$ - the thickness of the cut layer

The mechanical energy expended on the cutting process is converted into heat. The heat of cutting occurs in the cutting zone. The shavings are heated the most (up to 75% of the heat released), because it undergoes significant deformation. Up to 20% of the heat released is absorbed by the cutter, about 4% - the workpiece and about 1% is spent on heating the ambient atmosphere (Fig. 1.4).

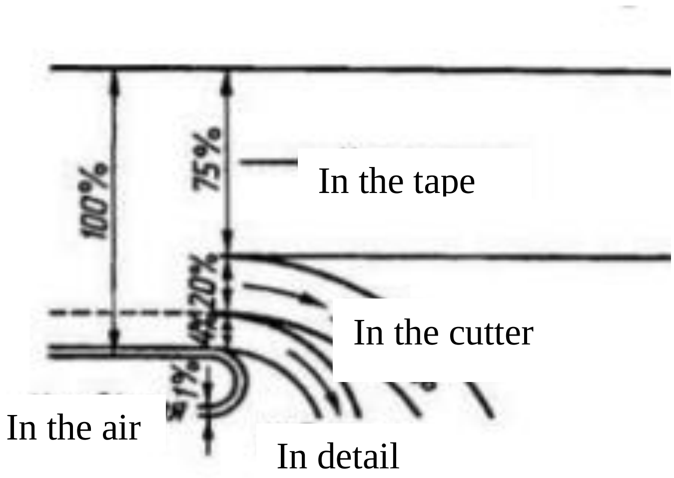

Figure 1.4 - Heat distribution of cutting

After blunting of the cutter the scheme of distribution of heat of cutting changes a little: the cutter and preparation heat up more. Steel chips, descending on the front surface of the cutter, has time to transfer much of its heat. Therefore the tool, having heated up from friction and having received additional heat from shaving, can overheat and lose the cutting properties. The cutting edge of the superheated tool acquires a blue shade and melts. Melting of the cutting edge is a consequence of incorrect choice of cutting mode. If the cutter is not damaged (melted), overheating will soften the cutting edge of the tool and speed it up.

On the front surface of the cutter, the chips “work out” a hole of depth ph (Fig. 1.5 a). In the case of further work, the depth increases and can reach the cutting edge and cause its destruction. But this practically does not happen, because the tool is pre-ground on the back surface. The hole, increasing the front angle of the cutter, facilitates the cutting process, so it is even useful. Friction on the cutting surface of the workpiece leads to the operation of the rear surface of the cutter: there is a platform height of h (Fig. 1.5 b). The greater the height of the site, the greater the friction, respectively, the more heat and the faster the further operation of the cutter, the size of the site increases, and this again accelerates the heating and abrasion of the tool. Significant operation of the rear surface is dangerous for the cutter, as it can lead to the destruction of the edge. Triggering occurs both on front, and on back surfaces (fig. 1.5).

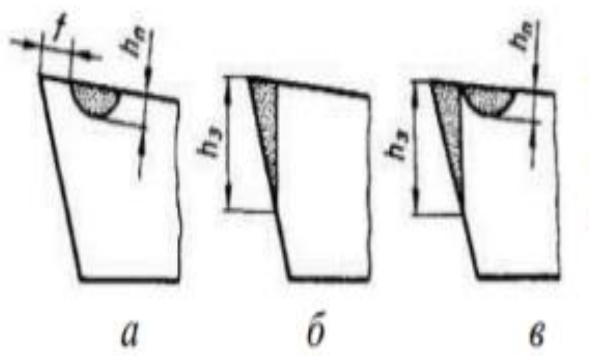

Figure 1.5 - Types of operation: a - on the front surface (hole); b - on the back surface (platform); c - on the front and rear surfaces

The operation of the cutter is due to the following reasons:

– direct scratching of the tool surface with solid particles of the processed metal, due to which the operation is called abrasive wear. It is characteristic of the processing of cast iron, which has an abrasive ability, ie intensively erases the surface of the tool;

– adhesion of the metal particles of the tool softened by heating to the rising chips and to the cutting surface (adhesion). The stronger the heating, the more intense the adhesion, and hence the operation of the tool due to the removal of metal particles of the tool. This operation is called thermal or adhesive wear. It is typical for processing steel and other viscous metals.

The cutter works unevenly. In the first minutes of the tool operation, the roughness on the blade and the thin layer, which has been dehydrated during hardening, are quickly erased. This is the so-called running-in wear. If the operation process is plotted graphically (Fig. 1.6), postponing on the horizontal axis the operating time of the tool T, and on the vertical - operation on the rear surface with h, the running wear is reproduced by the line AB (zone I).

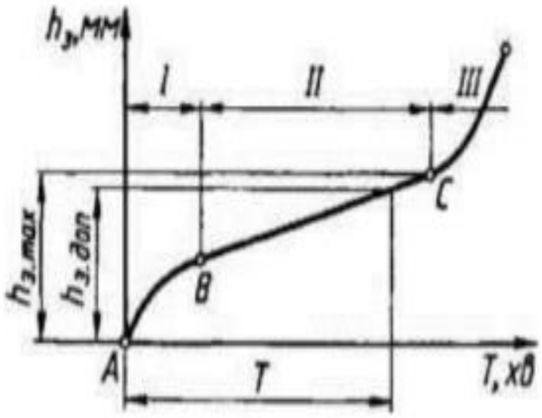

Figure 1.6 - The graph of dependence of operation of the cutter on a back surface on duration of its work: I, II, III - accordingly, zones of operation, normal operation and destruction (chipping); T - period of stability

Subsequently, there is a period of normal operation, over time, the height of the site h increases evenly (zone II, straight BC). When the height of the site reaches a certain maximum value $h_{з.max}$, further overheating of the cutter causes a sharp increase in the height of the site and the destruction of the cutting edge (on the graph, the line of operation goes up rapidly, zone III). To prevent accidental destruction of the edge of the cutter, it is sharpened in advance, ie when the operation reaches a certain allowable optimal value $h_{з.доп}$.

1.2 Methods of solving the problem

The purpose of material processing by cutting is to obtain new surfaces at the output with the given characteristics and its quality. This result is achieved by elastic and plastic deformation of the cut layer and the processed surface and is accompanied by wear of the contact pads of the cutting tool. These processes are completely simultaneously, closely related to each other and form a single system, which is called the cutting system.

The system has the property of relative stability, that is. it remains only within certain limits of variation of its variables. The system is characterized by the property of internal integrity, which is characterized by its autonomy, relative independence of behavior and existence. Due to its relative autonomy, any system can be considered. as a subsystem or element of a wider system.

To the input parameters of the system. cutting relative to: machine (M), device (D), tool (T), part (P) or MDTP for short, as well as the technological environment and cutting mode, to the days off: processing accuracy, surface quality, tool durability, strength of the institute , productivity, efficiency. In addition to those listed, other input and output parameters are possible.

M - material, S - size, A - allowance, Fпр and Fрв - functions connecting primary parameters with the cutting process and the cutting process with secondary parameters.

The cutting process is a complex physical and chemical complex. phenomena. The conditions for the course of the cutting process are determined by the kinematic cutting scheme, elastic and plastic deformations of the processed material, its destruction in the cutting zone, friction, thermal phenomena, chemical, electrical and magnetic phenomena, and other factors. In accordance with this, the cutting system can be divided into a number of particular subsystems: mechanical, thermal, etc. It should be noted that all subsystems are closed systems in which the output of the last element is associated with the input to the first .

In the theory of automatic control, open-loop and closed-loop systems are distinguished. If a change in the output value does not cause any change in the input, the system is called open-loop. Systems characterized by a closed cycle of transmission of influences are called closed.

The transfer of the influence of the output element to the input is carried out using feedback. If there is one such connection in the system, then the system is called single-loop, and if there are several, multi-loop.

Cutting is relative to multi-contour objects. regulation, since having a large number of regulated values, a change in each of which causes changes. other parameters.

However, for study. properties of individual elements, first of all, the cutting process, the system can be conditionally considered open, since the control action on the cutting process and secondary parameters comes only from the primary parameters.

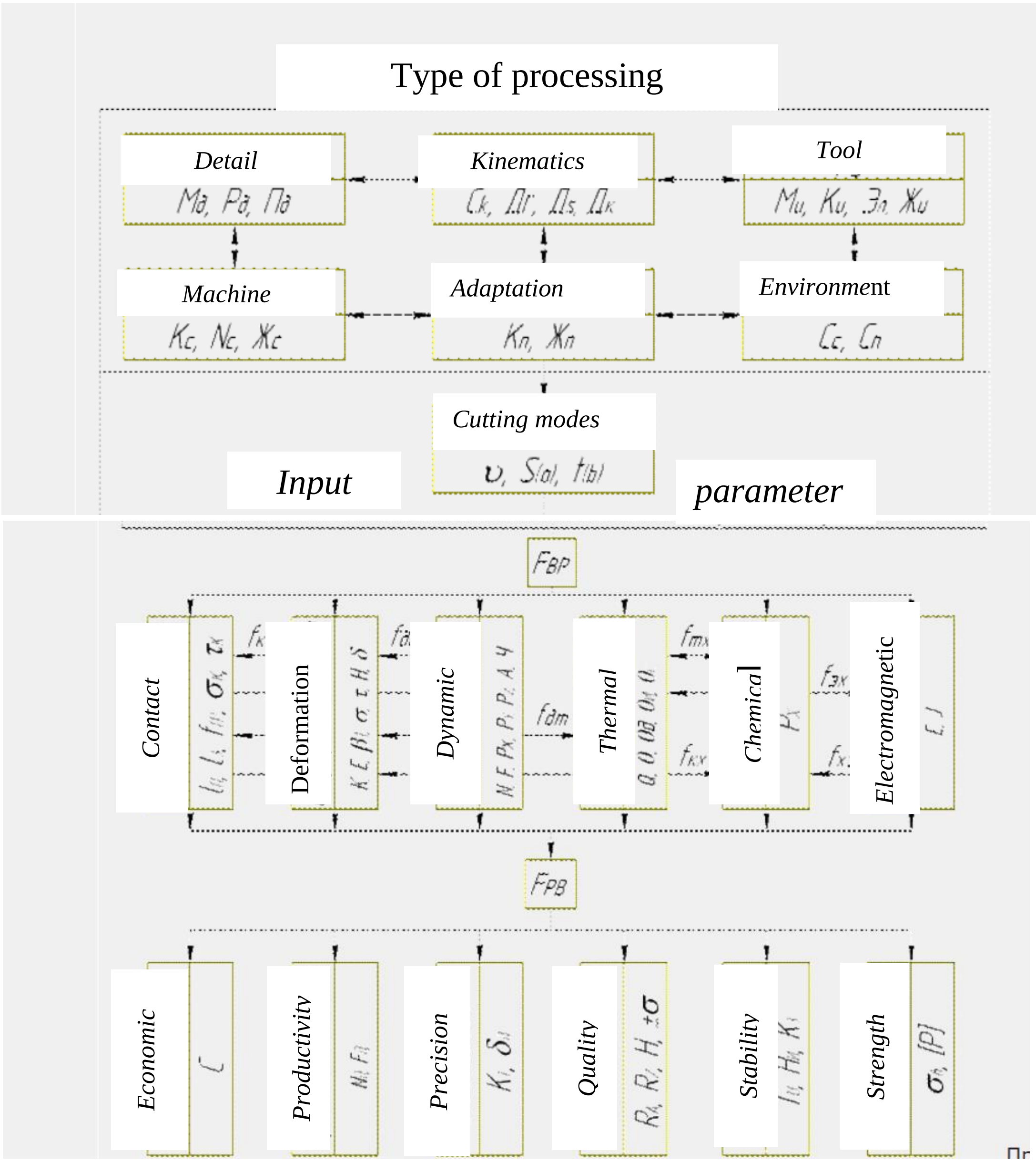

Figure 1.7 - Diagram of Incentive Mathematical Model

The object of regulation according to this scheme are all primary parameters and, first of all, a change in cutting conditions is used as a regulator ($P_{ж}$). In this case, the regulation of the processing process consists in obtaining the necessary parameters for the functioning of the system based on knowledge of the parameters of the part, the type of processing and the technological environment by changing the cutting mode.

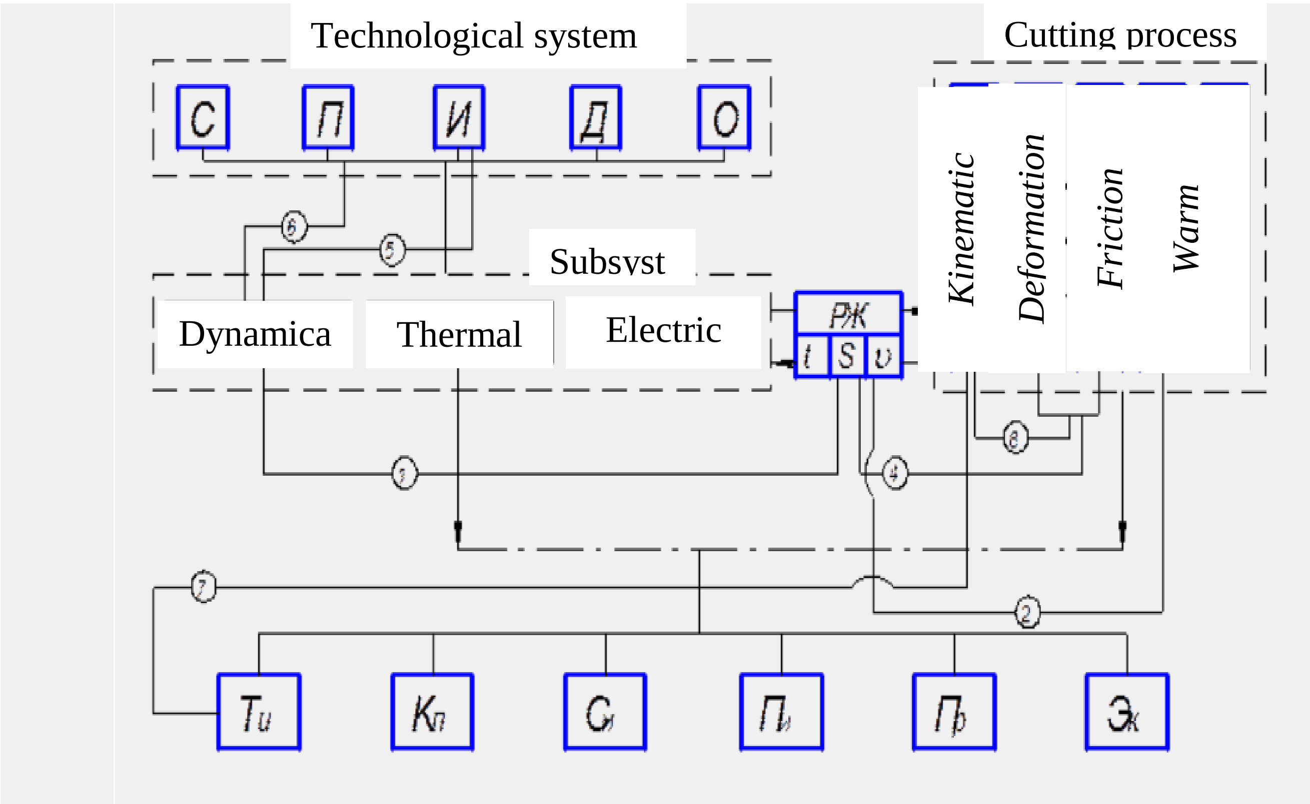

Figure 1.8 – ACS scheme

The interaction of the regulator with the elements of the system is carried out by feedbacks 1–7, for example, the feed S determines the properties of the dynamic system (link 1), which in turn depend on the design of the device P and the tool I (link 6 and 5).

The cutting speed υ mainly determines the thermal phenomena (link 2), and the kinematics of the cutting process affects the plastic deformations and friction (link 3) and the processing accuracy $T_ч$ (link 7). In this case, the supply S (link 4) is most often used as a regulator. Ultimately, the regulation of the properties of subsystems and the cutting process determines the output parameters - accuracy $T_ч$, surface quality $К_n$ durability $С_и$ and strength $П_и$ tool performance $Пр$ and economy $Эк$ of processing.

1.3 Conclusions and tasks for qualification work

Calculation and explanatory note to the thesis contains the characteristics of the production object, determining the type and organizational form of production, the necessary technological and design, economic issues, life safety issues.

The economic substantiation of the designed variant of the technological process confirms the feasibility of its introduction into production.

Developed in the graphical part of the drawings of the devices can be used to attach the entire given nomenclature, that is, has a universal reconfigurable character. Automating tool replacement and adjusting it to a predetermined size outside the machine and changing the tool during non-working hours significantly increase the machine utilization rate, increase the percentage of machine time in the machine cycle up to 75%. The use of progressive cutting and auxiliary tools helps to increase productivity.

The diploma thesis is developed on the theme of organization of production of typical representatives of details of type "nave" taking into account the program of production and analysis of technical conditions of drawing, manufacturability, choice of the most economical variant of preparation of billets on the basis of calculation of minimum allowances for all intermediate technological transitions. The task is to develop the most rational technological route of manufacturing parts, taking into account the use of progressive devices, machine tools, cutting tools, mechanization and automation of transport operations, which contribute to reducing the production preparation time, improving the quality of production and increase productivity.

2 RESEARCH PART

2.1 Characteristics of the object or subject of research

Machining by cutting with blade cutting tools is characterized by the force of interaction of the working surfaces of the tool blade with the layer of allowance to be cut and the surfaces of the workpiece being processed. The force of interaction of the tool with the workpiece consists of the force of chip formation required to deform the cut allowance layer in the cutting zone, the force of contact interaction of the chip with the front surface of the tool, and the force of interaction of the rear surfaces of the tool with workpiece surfaces. when the surfaces of the tool wear. The last two components of the cutting force are essentially friction forces. The sum of these components creates the processing force of a given surface, which is a vector and is characterized by magnitude and direction. In the process of processing as a result of fluctuations of the allowance for processing and variability of mechanical characteristics of the processed material the size and direction of force of processing changes that creates additional difficulties of calculation of characteristics of process of cutting. In the process of processing as a result of fluctuations of the allowance for processing and variability of mechanical characteristics of the processed material the size and direction of force of processing changes that creates additional difficulties of calculation of characteristics of process of cutting.

To ensure the study of the physical laws of different types of cutting, the processing force is decomposed into three components in the orthogonal coordinate space of the axes *OZ, OY* and *OX.* The main axis *OZ* coincides with the direction of the velocity vector of the main cutting motion. Accordingly, the projection of the machining force on the axis *OZ* called the main component $P_:$ cutting force, and if the main cutting motion is rotational, it is also called the tangent component of the machining force.

Axis *OX* coincides with the axis of the main movement of the cutting workpiece or tool and is called the axial component P_x *of* cutting force. The last, orthogonal coordinate *OY* directed along the radius of the workpiece or the radius of the cutting tool and is called the radial component P_y cutting forces (Fig.2.1). Representation of the machining force by its components provides determination of the characteristics of the cutting process, namely: cutting power, machining accuracy, load of the cutting tool and its deformation, load on the elements of the kinematic chain of the feed mechanism, the amount of heat released during cutting. Accordingly, knowledge of the force characteristics of the machining process allows to calculate and predict the elastic deformations of the TDT, thermal deformations of tools, workpieces or parts of machine tools. Machining conditions and evaluate self-oscillations occurring in the elastic TDT.

Machining force is determined by the influence of a large number of factors that act in the cutting process, among which the greatest influence is created by the cutting mode: h - cutting depth, S - longitudinal feed, V - cutting speed; geometric parameters of the cutting part of the tool; physical and mechanical characteristics of the processed material; physical and mechanical characteristics of the tool material, as well as the characteristics of the lubricating and cooling technological environment

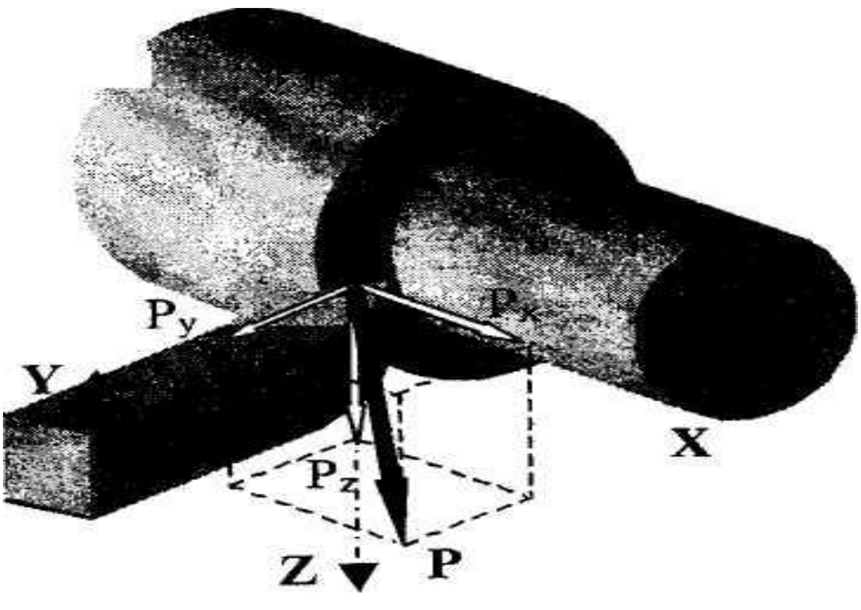

Figure 2.1- Scheme of the decomposition of the cutting force into components during turning

The significant increase in the value of optimizing the conditions for metal processing by cutting is explained not so much by the extensive automation of machine-building production and the use of CNC technological equipment. By the fact that this will allow finding such conditions for the implementation of technological solutions in which it will be possible to produce high-precision parts with minimal labor intensity. Therefore, taking into account the probabilistic nature of the cutting process, it can be assumed that the output parameters of the processing process are significantly affected by its reliability. The importance of the reliability of the machining process increases with increasing requirements for the quality and accuracy of the manufactured part. Only with sufficient reliability is it possible to obtain stable (in time) parts of a certain shape and size, with strictly regulated physical and mechanical properties of the surface layer. The latter is very important when creating so-called repair technologies. Under conditions of surface restoration of parts by surfacing and subsequent blade processing using RI from composites, significant fluctuations in both the allowance and the physical and mechanical properties of the metal are possible. Taking these factors into account and managing them with a combination of a given processing accuracy, high productivity and the lowest possible cost are the main interrelated conditions for optimizing the TP of manufacturing parts. The task of optimizing the metal cutting process in the general case consists of a number of successively carried out and interrelated stages: description of the processing process; determination of qualitative and quantitative factors affecting its results. Choice of optimization criterion; setting restrictions on this criterion and input parameters; building a process model; selection of an optimization method and finding a control algorithm that provides an extreme value of the selected optimization criterion; solving the problem with the subsequent verification of its significance. The description of the processing process, in addition to setting the research problem, should contain information about the studied dependencies, the nature of their interaction, complexity, controllability and reproducibility of the process. In this case, it is also necessary to take into account the instability of physical and mechanical properties and the difference in the quality indicators of the surfaces of parts formed in the previous operation, fluctuations in the allowance, changes occurring in the vehicle, and their influence on the quality and productivity of processing [2]. Any part processed by cutting can be described by a set of features: the shape and design features of the machined surfaces; material and its physical and mechanical properties; quality and accuracy of processing, etc.

There is practically no need to use a complete list of features, since a deep analysis of the investigated dependencies makes it possible to establish a minimum of quantitative characteristics that need to be known to solve the TP optimization problem. Determination of quantitative factors consists in processing data on the state of the process under study by mathematical methods, followed by replacing these data with appropriate functions that are easily subject to mathematical analysis to assess the characteristics of the process. The processing of data on the state of the manufactured part must meet the requirements established for the TP. Therefore, to assess the projected TP it is necessary to have appropriate design quality criteria.

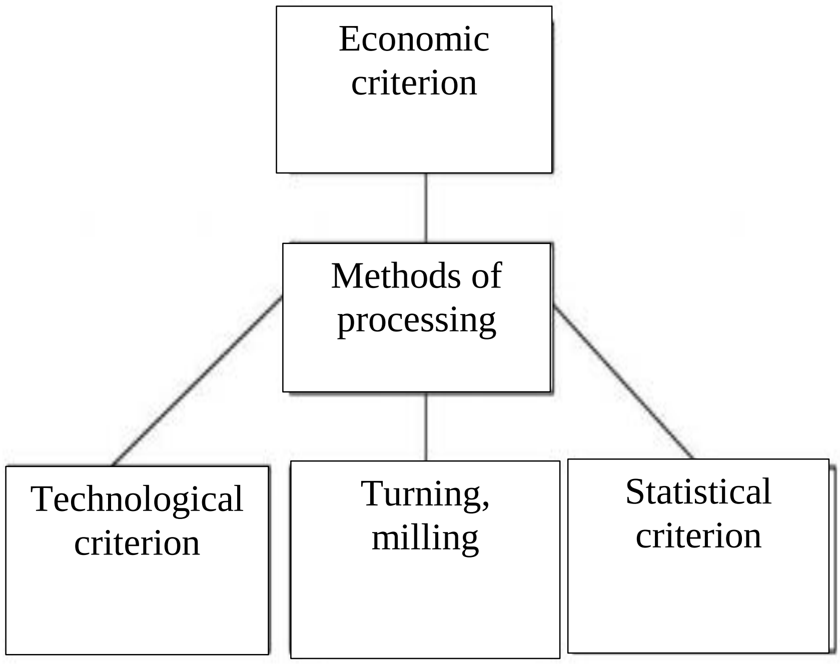

Figure 2.2 - Evaluation criteria

Evaluation criteria (Fig. 2.2) are selected based on the purpose of the study and the nature of the process. The most common criteria are economic (minimizing the cost of manufacturing a part), technological (quality, accuracy, productivity), statistical, etc.

2.2 Processing of research results

The known optimization methods (Fig. 2.3) differ in content. The choice of the optimization method consists in finding the optimal conditions for the implementation of the investigated TP in order to obtain the best results that satisfy the conditions of the task. From the conditions for the implementation of the investigated TP, we will single out the factors that most strongly affect the functioning of its model and vary in a wide range depending on specific production conditions. These include the material and condition of the treated surface, the grade of the composite, the modes cutting and geometry of the cutting part of the RI. The task of optimizing cutting conditions within technological operation is reduced to optimizing the functioning of the formed TP model and mathematically can be solved in two stages. At the first stage, a combination of widely varying factors is optimized to provide cutting conditions that contribute to the achievement of a given part quality. As a goal (parameter) of optimization, one most often chooses the resistance of RI or wear of the cutting insert along the flank surface. At the same time, such a combination of the studied factors is found that can provide the maximum possible resistance of the RI (minimum wear) or a given value of the technological criterion, for example, the surface roughness. Cutting conditions at the first stage do not vary; their meanings are taken at the basic level. At the second stage, cutting conditions are optimized according to the criterion of technological cost. The target function in this case is the dependence of the technological cost on the accepted processing modes, the type and condition of equipment, tooling, and the conditions for organizing production. To compile it, the technologist must know the specific production environment and the dependence of the technological criterion on the processing mode. This allows for adaptive control of the cutting conditions.

$$\begin{cases} P_z = C_{Pz} h^{X_{Pz}} S^{Y_{Pz}} V^{n_{Pz}}; \\ P_{xy} = 0{,}6 P_z; \\ v = arctg\left(\dfrac{S_{об} Sin(\varphi+\varphi_1) Sin^2\varphi}{hSin(\varphi+\varphi_1) + S_{об} Cos(\varphi+\varphi_1) Sin^2\varphi} \right); \\ (P_z)_0 = P_z + P_y (CosvSin\gamma Cos\lambda - SinvSin\lambda); \\ P_y = P_{xy} (SinvCos\lambda Sin\varphi + CosvSin\gamma Sin\lambda Sin\varphi + CosvCos\gamma Cos\varphi); \\ P_x = P_{xy} (CosvCos\gamma Sin\varphi + CosvCos\lambda Cos\varphi + CosvSin\gamma Sin\lambda Cos\varphi); \end{cases} \quad (2.1)$$

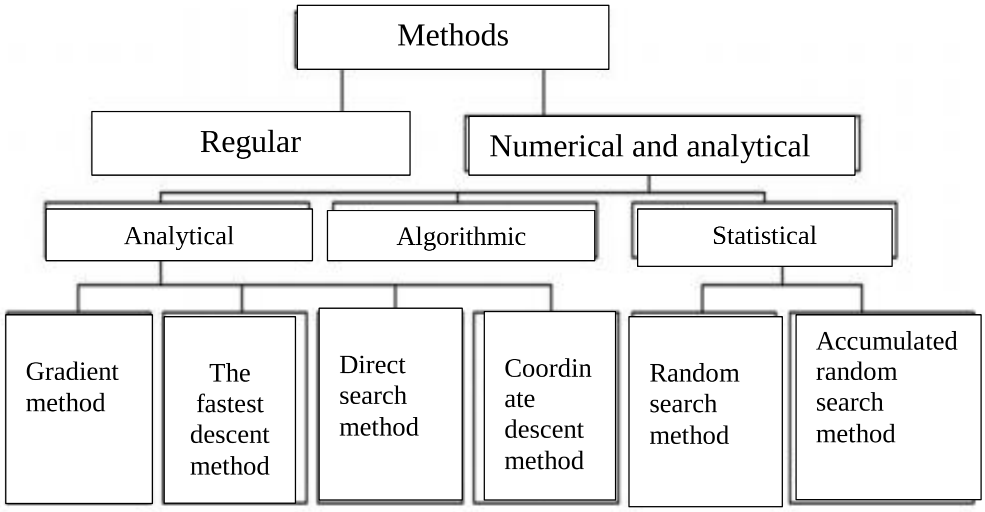

Figure 2.3 - Choice of optimization method

Thus, the mathematical model for determining the components of the cutting force along the coordinate axes XYZ in accordance with the literature.

Thus, the adequacy of modeling is limited by the fact that the mathematical model ignores the processes of wear of the cutting tool, static and dynamic characteristics of the TOC, random perturbations, thermal phenomena and so on.

The depth of cut varies in the range *h = 0,2...4,0 mm with discreteness 0,1 mm*; longitudinal feed -*S = 0,05...0,5 mm / rev with discreteness 0,01 mm / rev; cutting speed* - *V = 10...200 m / min with discreteness* 1 *m / min; the main angle in the plan* - φ *= 30. ..90°;* front corner -γ *= 0... 15°;* the angle of the cutting edge - λ = - 5...5^0 all with discretion *1°*. The auxiliary angle in the plan in the study is assumed to be constant and is selected from a range of values φ = *30-45-60°*.

The study of the influence of variable parameters on the components of the cutting force is carried out according to the "classical" method of one-factor experiments, namely, successive studies are performed at constant values of all other parameters. The ranges of parameter changes in the function of which the research is performed are given above. The results of the performed research should be entered into the tables of experimental data, according to which to build appropriate graphs of the dependences of the components of the cutting force on the variable parameters of the machining process.

Table 2.1.- Initial data

Material		φ_1, degrees	h ,mm	V,m/min.	γ, degrees	S, mm/rev	φ, degrees	λ, degrees
blank	tool							
Cast iron СЧ35-10	ВК8	30	1,5	100	9	0,25	60	-5

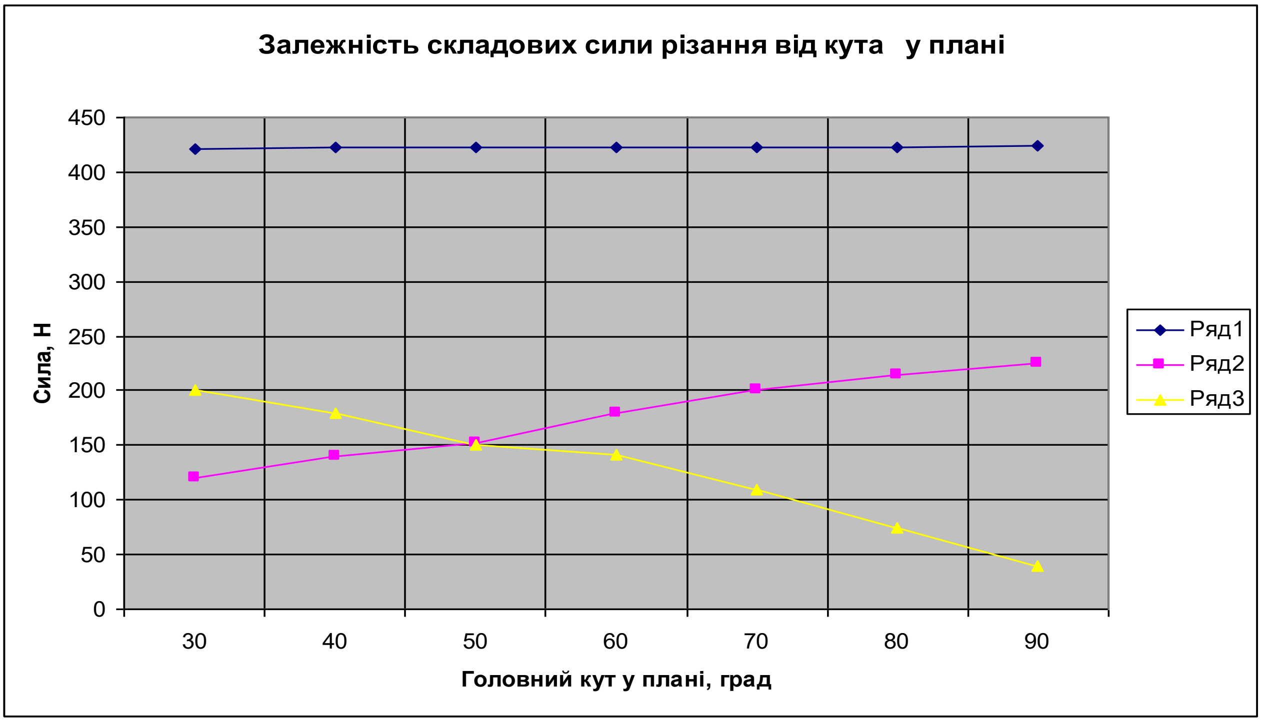

Figure 2.4 - Dependence of the components of the cutting force on the angle φ in the plan

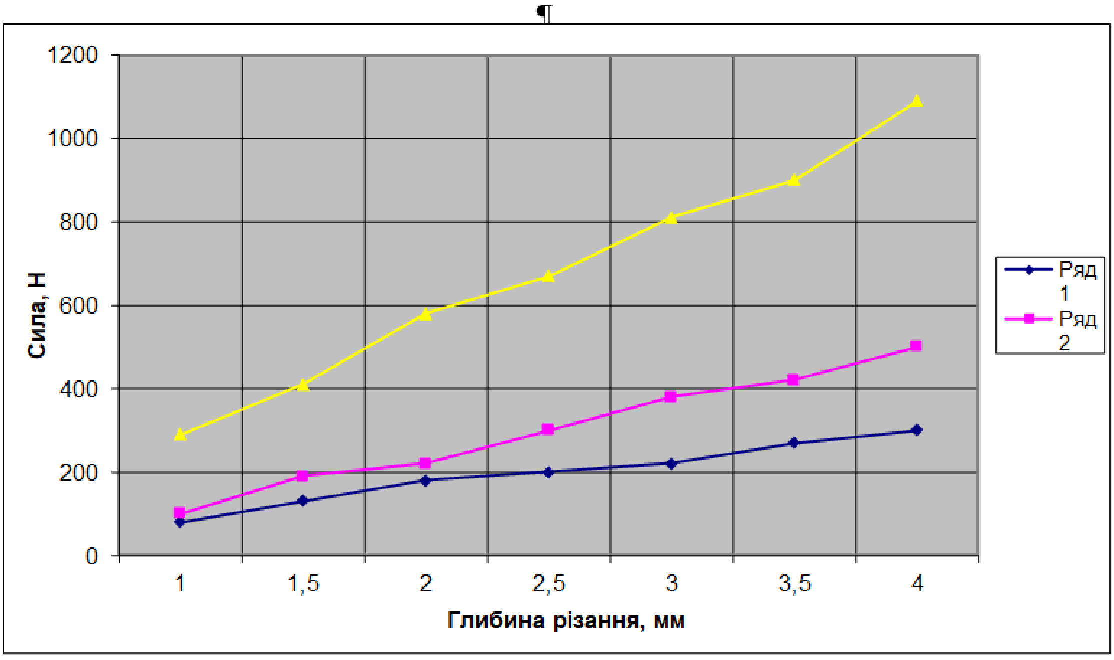

Figure 2.5 - Dependence of the components of the cutting force on the depth of cut

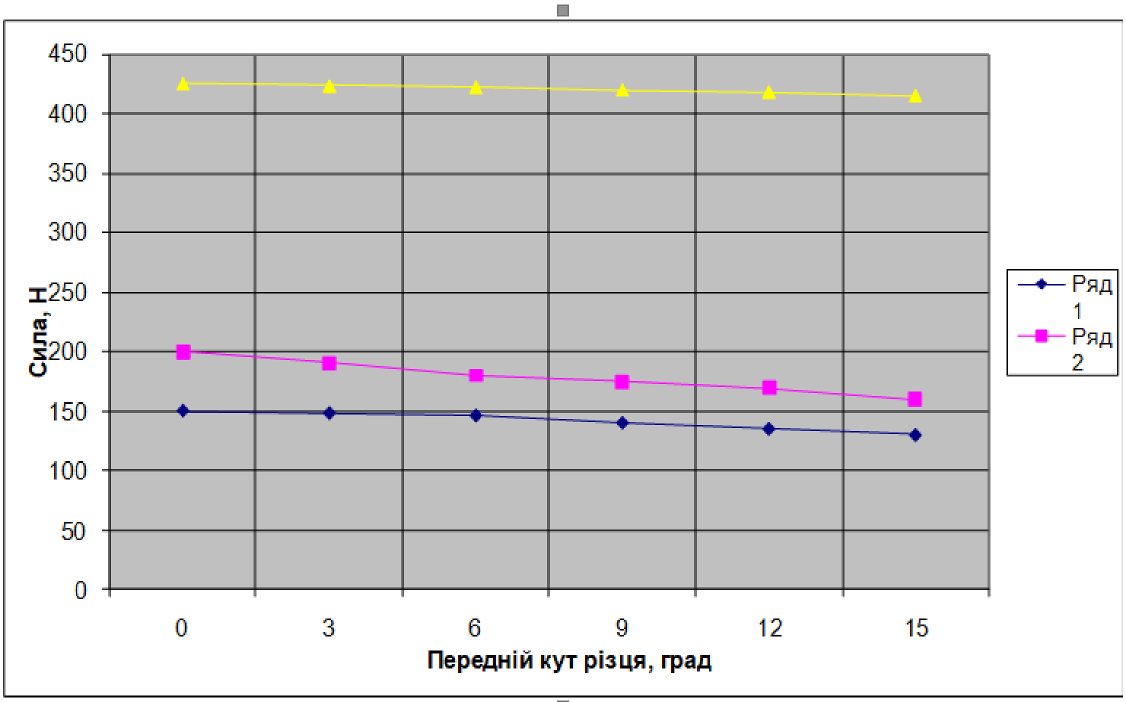

Figure 2.6- Dependence of the components of the cutting force on the front corner of the cutting edge

2.3 Analysis and generalization of the received information

The selected optimization criterion must be universal, comprehensively characterize the process and provide an unambiguous measurement result, i.e., a single value of the optimization criterion must correspond to a given array of values of the input variable factors. Therefore, if several optimization criteria appear in the process of research, the problem does not have an unambiguous solution. In this case, two practically equivalent ways are possible: optimization according to the criterion most important for research under the constraints imposed by other solutions, or optimization according to each criterion separately with subsequent mathematical generalization, modeling and verification. Blade processing processes are characterized by multifactorial input parameters and are discrete in nature; therefore, any of them should be considered as the integration of separate stages (technological operations). It should be borne in mind that, depending on the specific production conditions, almost any TP operation can be implemented in different ways. The introduction of a number of restrictions makes it possible to significantly narrow the range of permissible values of the factors under study, to increase the reliability and significance of the optimization criterion, as well as to simplify the problem being solved, to make it convenient for solving with the help of modern computer technology. The use of a computer and modern mathematical apparatus makes it possible to determine the most appropriate processing method for each TP and specific production conditions. Optimization of the processing method is a prerequisite for the optimization of the entire TP [3]. The most effective and acceptable method of machining is selected according to technical and economic indicators. From the possible combinations of operations, a complex model is formed, which makes it possible to identify the features of a particular TP. Simplification of the real TP, replacing it with an abstract mathematical model makes it possible to fairly reliably and accurately investigate individual stages of TP and select the optimal conditions for its implementation. Establishing correspondences between the input parameters and the results of experiments in the form determined by the conditions of the problem posed is the basis for constructing a TP model. Such a model can be deterministic or random, as well as describe the properties of TP by a system of empirical dependencies. The main method for obtaining statistical models is mathematical planning of the experiment.

2.4 Conclusions and suggestions on the use of research results

Integration of the adaptive control system of the cutting process, the metal-cutting machine and statistical optimization models is one of the promising areas. It allows you to find the optimal parameters by calculation, which are then refined during processing using adaptive control systems. The analysis of the experimental deposits allows the formation of offsets, so that they can adapt to a pre-juvenile range of development for the values at the butt of materials in the tool and workpieces:

1. Increasing the main angle of the cutter in terms of almost no change in the cutting force, the component P_x does not change, component P_y decreases, component P_z increases. Such changes will cause corresponding changes in the components of the processing error due to the elastic deformations of the TOC.
2. Increasing the depth of cut causes a proportional increase in the cutting force and its components almost linearly.
3. Increasing the angle of the main cutting edge causes a decrease in the cutting force and all its components. This indicates improved cutting conditions and reduced energy losses to remove the allowance.

3.TECHNOLOGICAL AND DESIGN PART

3.1 Purpose and characteristics of the object of production

Considering the drawing of the details we conclude that the surfaces Б, В, Г, Н are crucial in determining the service purpose of the wheel body.

These surfaces have a high accuracy class P7 and must be made to 1.6 accuracy class, and in the drawing it is seen that the mutual placement of these surfaces is interrelated. The co-axis of these surfaces is 0.15mm and the radial beating of the surface Б and В not more than 0,12mm. All other surfaces to be treated must be of the 14th accuracy class. The workpiece itself must be made to the accuracy class II.

Material details malleable cast iron 35-10.

The minimum value of temporary resistance is 180 MPa.

The flexural strength of 280-320 MPa. The chemical composition of ductile iron 35-10 will be considered in the table 3.1.

Table 3.1 - Chemical composition

C, %	Si, %	Mn, %	P,%	S,%
2,2-3,2	0,8-1,5	0,3-1,0	<0,18	<0,12

The brand of this cast iron is used mainly for casting low-loaded parts of agricultural machines, tractors, forklifts, fittings.

The part has two surfaces ∅120 and ∅90 for planting bearings. In technical terms, the concentricity of the axes of these openings is indicated. An important requirement of the drawing is also the tolerance of the perpendicularity of the end of the flange to the axis of the hole ∅120 mm, 6 holes must also be machined with the required accuracy ∅22 mm, through which the wheel attaches to the pivoting fists of the beam. After machining, the rough surfaces must be coated with a primer.

The wheel housing is an integral part of the rear beam and serves to attach the wheel disks to the beam.

The beam, in turn, is an integral part of the forklift. Forklifts are used to carry out loading and unloading operations.

Working out details for manufacturability. The manufacturability of the parts is evaluated by two parameters: qualitative and quantitative.

Qualitative assessment of the manufacturability of the parts is carried out on the material, geometric shape, quality of surfaces, the formulation of sizes and possible methods of obtaining workpieces.

Concerning the characteristics of the quality level, we can state the following:

1. The material proposed for the manufacture of the wheel housing makes it possible to obtain the workpiece by casting.
2. Parts have convenient base surfaces.
3. The accuracy and roughness requirements for most machined surfaces are small, allowing for one-time machining.
4. Parts have the ability to create convenient finishing bases that allow machining of surfaces with high precision using the principle of constancy and unity of bases.
5. The axes of all the main openings are arranged parallel or perpendicular to the planes of the base.

The design of the part provides the opportunity to use the optimal technological process, equipment, applicable to production conditions.

Quantitative assessment is carried out in absolute and relative terms. First of all, it is necessary to set the indices of the base part: material utilization rate, machining accuracy, surface roughness, manufacturing complexity, technological cost.

1. The coefficient of unification of the elements:

$$K_{y.e.} = \frac{Q_{y.e}}{Q_e}, \tag{3.1}$$

where $Q_{y.e.}$ - the number of unified surfaces and structural elements (corners, holes, chamfers and others);

$Q_{e.}$ - the number of all surfaces;

Uniform coefficient for cylindrical surfaces:

$K_{y.e.} = \frac{36}{50} = 0.72 \rangle 0.6$, detail refers to technological.

2 Coefficient of processing accuracy:

$$K_{T.O.} = 1 - \frac{1}{A_{cp}}, \tag{3.2}$$

where $A_{cp.}$ - average quality precision of size, where numbers indicate the quality number;

$$A_{cp.} = \frac{n_1 + 2n_2 + 3n_3 + ... + 19n_{19}}{\sum n_i}, \tag{3.3}$$

where $n_{1...}n_{19}$ - the number of dimensions of the relevant quality;

$$A_{cp.} \frac{7 \cdot 2 + 8 \cdot 1 + 11 \cdot 3 + 14 \cdot 16}{25} = \frac{312}{25} = 12.48;$$

$K_{T.O.} = 1 - \frac{1}{12.48} = 0,92 > 0,8$ detail is technological;

It can be concluded that the accuracy of the part belongs to the class of average accuracy.

The coefficient of roughness:

$$K_{ш.} = \frac{1}{Ш_{cp.}}, \tag{3.4}$$

where $Ш_{ср.}$ - average surface roughness;

$$Ш_{ср.} = \frac{0,01n_1 + 0,02n_2 + ... + 40n_{13} + 80n_{14}}{\sum n_i}, \quad (3.5)$$

$$Ш_{ср.} = \frac{744.1}{25} = 29.8;$$

$$K_ш = \frac{1}{29.8} = 0,033$$

According to the coefficient of roughness, the workpiece does not belong to a difficult machining.

To estimate the coefficients, consider the table 3.2.

Table 3.2 - Surface treatment methods

Surface (dimensions)	Quality	Roughness Ra
Ø90 ; Ø120	7	1.6
Ø22	8	1.6
58,5; 77,5;	11	3.2
M8;	11	12.5
Ø145; Ø150; Ø125; Ø275;	14	50
Ø78; Ø105; Ø12,2; Ø114;	14	50
8; 10;	14	50
4;	14	12.5
20;	14	6.3
180; Ø158;	14	12.5
R18; R2;	14	50
8;	11	1.6
13	11	50

Analysis of the basic technological process. In the existing technological process, castings in earthen forms are used as blanks. The accuracy of casting and allowances allow to obtain the dimensions specified in the drawing and the required precision of processing. Consider the existing technological process.

Operation 005 Screw-cutting:

In this operation, surfaces 1-7 are sequentially treated. In this case, to improve the technical process, instead of machines of universal model 163, you can use a turning machine 1283 and instead of three cam cartridge - pneumatic.

Operation 010 Screw-cutting:

Surfaces 8-12 are processed. Similar to the first operation. Instead of the universal machine 163 and three cam cartridge, it is advisable to use the turning semiautomatic device of model 1Б284 and the pneumatic cartridge.

Operation 015 Radial drilling:

6 holes are processed sequentially ∅22. For improvement of technological process on this operation it is possible to use the aggregate-boring machine with a rotary table, or 6 spindle heads.

Operation 020 Vertically drilling:

Four holes are sequentially machined ∅15 on the radial-drilling machine model 2H55. In this operation, can be used a vertical drilling machine with four spindle drilling head. However, a combination tool can be used.

In general, considering the existing technological process, we can conclude that the processing is carried out mainly on universal machines and universal equipment. It is advisable to use semi automats and special equipment to improve the process. It will also enable the use of a progressive cutting tool. Such changes will improve the quality of the workpiece, accuracy and reduce the time for their processing.

A more detailed analysis of the existing technological process will be carried out in the following sections.

3.2 Development of the technological process of manufacturing the product

Based on the increased series of parts, the following principles are used in the design of the process:

1) Maximum concentration of operations and transitions performed in one operation.
2) Use rational shapes and workpiece sizes and minimum machining allowances to simplify cutting tool nomenclature and improve productivityi.
3) Where it is possible to combine rough work with finishing.
4) Designing the process for operations must ensure that all technological requirements are met at maximum performance that is determined:
   a) sequence of technological transitions;
   b) technological capabilities of the machine;
   c) cutting tool capabilities;
   d) the amount of operating allowances.

Based on the analysis existing at the plant technological process, we develop a promising technological process, which eliminates all the disadvantages.

Parts are machined on metal-cutting machines, without using unique machines. A standard cutting tool is used for machining.

A large number of surfaces are processed in one installation. Each subsequent operation reduces the error and improves the surface quality.

First, the surfaces from which the largest metal layer is removed is processed.

Consider the technological route of processing the details "wheel body" table 3.3

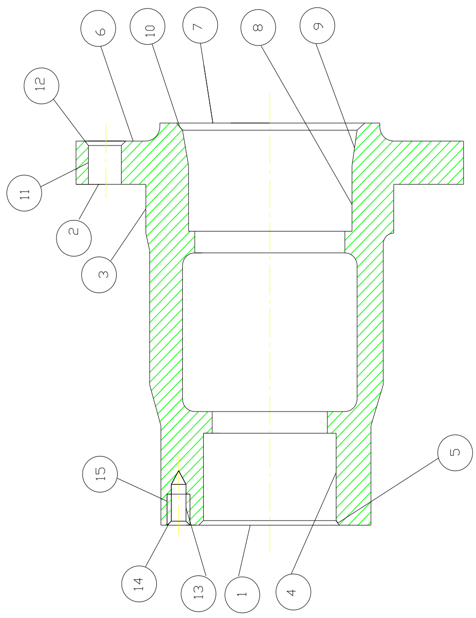

Figure 3.1 - Wheel housing

Table 3.3 - Operations and tools

№ of operation	The name and composition of the operation	Equipment	Cutting tool
1	2	3	4
005	Turning 1. trim the end face 1. 2. trim the end face 2 rough and surface 3 toØ158. 3. trim the end face 2 clean. 4. rough drill of hole 4. 5. clean drill hole 4. 6. bore out facet 5. 7. clean ream hole 4. 8. thin ream hole 4.	Lathe semiautomatic device 6 spindle 1283	Cutter 2110-0006 ГОСТ 18878-73 Cutter 2112-4005 ГОСТ 18878-73 Різець 2142-0052 ГОСТ 9795-73 Cutter 2112-4005 ГОСТ 18879-73 Cutter 2142-0052 ГОСТ 9795-79 Cutter 2120-4188 ГОСТ 18875-73 Reamer 2367-4170 ГОСТ11176-71 Reamer 2367-4131 ГОСТ 11176-71

010	Токарна 1. rough cut the end 6. 2. rough cut the end 7. 3. clean cut the end 6. 4. clean cut the end 6. 5. rough bore out the hole 8. 6. clean bore out the hole 8. 7. bore out surface 9 under the cone 8o 8. remove the facet 10. 9. ream out the hole 8 in advance. 10. thin ream out the hole 8.	The turning semiautomatic 8 spindle device 1Б284	Cutter 2112-4005 ГОСТ 18879-73 Cutter 2110-0006 ГОСТ 18876-73 Cutter 2112-4005 ГОСТ 18879-81 Cutter 2110-0006 ГОСТ 18876-73 Cutter 2142-0052 ГОСТ 9795-73 Cutter 2142-0052 ГОСТ 9705-73 Cutter 2101-4059 ГОСТ 18879-73 Reamer 2367-4169 ГОСТ 11176-71 Reamer 2367-4145 ГОСТ 11176-71
015	Aggregate-boring 1. drill 6 holes 11 at the same time 2. Counter 6 holes. 11 with the simultaneous removal of the chamfer 12. 3. bore out 6 holes. 11 at the same time	Aggregate drilling 2Г175 3-position	Drill 2301-0069 ГОСТ 10903-77 Mill 2337-4025 ГОСТ 3221-71 Reamer 2367-4121 ГОСТ 11176-71
020	Vertically - boring Drill 4 holes 13 with the simultaneous removal the chamfer 14.	Vertically drilling 2А150	Drill 2300-0309 ГОСТ 10903-77
025	Vertically - boring Cut the thread 15 in 4 holes at a time.	Vertically drilling	The tap 2620-1221 ГОСТ 3266-81 The threaded plug M8 8221-3036 ГОСТ 17758-72

The total value of the roughness and accuracy parameters R_Z and T, for casting is determined by the table 4.3 [7]. For the rest of the conversions, we define R_Z by the table 4.5[7]. For cast iron T we do not define.

Table 3.4 - Surface treatment route

Technological transitions of surface treatment Ø $120^{-0.024}_{-0.059}$	Elements of allowance microns				Calculated allowance, microns $2Z_{\min}$	Calculated Size, microns	Tolerance, , microns	Limit size microns		Boundary value of allowances, microns	
	R_Z	T	ρ	ε				h	d max	$2Z^{np}_{\min}$	$2Z^{np}_{\max}$
1	2	3	4	5	6	7	8	9	10	11	12
The workpiece	700	-	2002	-	-	114,03	2000	112,03	1103	-	-
Rough boring	50	-	100	600	$2 \cdot 2702$	119,43	540	118,9	119,44	5410	6870
Clean boring	20	-	80	30	$2 \cdot 150$	119,73	220	119,5	119,74	300	620
Normal reaming	10	-	10	-	$2 \cdot 100$	119,93	140	119,8	119,94	200	280
Thin reaming	5	-	-	-	$2 \cdot 20$	119,97	35	119,94	119,98	40	140
Total									Σ	5950	7910

Determination of allowances and operating sizes/ Several methods are used to calculate allowances. We calculate machining allowances and intermediate sizes for the hole Ø$120^{-0.024}_{-0.059}$. The calculation is carried out according to the method set out in the literature [7].

The workpiece is a cast of the second accuracy class, weighing 15.4kg. the base is a plane and a cylindrical surface. We compile Table 2.6, in which we enter the route of surface treatment.

Depending on the conditions of operations, we use the formula to determine the spatial deviations for the workpiece:

$$\rho = \sqrt{\rho_1^2 + \rho_2^2}, \tag{3.4}$$

where ρ_1- specific warping of the casting hole,must be taken into account the diametrical and main cross sections. microns;

ρ_2 - total displacement of the casting hole, microns;

$$\rho_1 = \sqrt{(K \cdot d)^2 + (K \cdot l)^2}, \tag{3.5}$$

where $K = 0.7$ μm / m - specific warping of the casting;

$d = 120$ mm - diameter of the hole;

$l = 58.5$ mm - length of the hole.

Then:

$$\rho_1 = \sqrt{(0.7 \cdot 120)^2 + (0.7 \cdot 58.5)^2} = 93 \text{ мкм} = 0.093\text{mm};$$

In this case, we define as the deviation from the nominal size in the casting, which is determined by the tolerance on the size for the second accuracy class, $\rho_2 - 2000$ microns.

$$\rho = \sqrt{93^2 + 2000^2} = 2002 \text{ мкм.}$$

The other spatial deviations after machining will be equal:

Rough boring:

$$\rho_ч = K_y \cdot \rho = 0.05 \cdot 2002 = 100 \text{ microns.}$$

K_y - refinement coefficient form.

Clen boring:

$$\rho_ч = 0.04 \cdot \rho \ = 0.04 \cdot 2002 = 80$$ microns.

Normal boring:

$$\rho_н = 0{,}005 \cdot \rho = 0.005 \cdot 2002 = 10$$ microns.

Installation error during roughing is determined by the formula:

$$\xi_y = \sqrt{\xi_\delta^2 + \xi_з^2}\ , \qquad (3.6)$$

where ξ_δ - base error, ξ_δ =0;

$\xi_з$ - fixing error by the table 4.10[7]. $\xi_з$ =600 microns.

$$\xi_y = \sqrt{0^2 + 600^2} = 600$$ microns.

Residual error during clean boring:

$$\xi_2 = 0.05\xi_1 + \xi_{in} = 0.05 \cdot 600 = 30$$ microns.

Since the roughing and finishing boring is done from one installation, then $\xi_{in} = 0$.

In this case, the part is installed in a three-piston pneumatic cartridge, and thus the technological and installation bases coincide, and the surface treatment is carried out from one installation, the installation error is taken to be zero.

Based on the data recorded in the table, we calculate the minimum values of inter-operative allowances using the basic formula:

$$2Z_{\min} = 2(R_{Z_{i-1}} + T_{i-1} + \rho_{i-1}), \qquad (3.7)$$

Minimum allowance for boring:

Rough: $2Z_{\min 1}$=2(700+2002)= $2 \cdot 2702$ microns;

Clean: $2Z_{\min 2}$=2(50+100)= $2 \cdot 150$ microns

Reaming:

Normal: $2Z_{\min 3}$=2(20+80)= $2 \cdot 100$ microns

Accurate: $2Z_{\min 4}$=2(10+10)= $2 \cdot 20$ microns

The column "estimated size" is filled in from the final size, from which we subtract the estimated minimum allowance of each technological transition.

$d_{p1} =$ 119.976-0.040=119.936 mm;

$d_{p2} =$ 119.936-0.2=119.736 mm;

$d_{p3} =$ 119.736-0.3=119.436 mm;

$d_{p4} =$ 119.436-5.402=114.034 mm.

The tolerance values of each technological transition are accepted by the tables. In the limit size column, we take the largest value rounded to the nearest tolerance of the corresponding transition, to determine the smallest limiting dimensions ($d_{\min}$) from ($d_{\max}$) subtract the tolerance values of the corresponding conversions.

Minimum allowance limits in $Z_{\min}^{np}$ equal to the difference of the largest boundary dimensions of the transition, and the maximum values - respectively, the difference of the smallest boundary dimensions.

$2Z_{\min 4}^{гр}$ =119.98-119.94=0.04мм=40 microns;

$2Z_{\min 3}^{гр}$ =119.94-119.74=0.2мм=200 microns;

$2Z_{\min 2}^{гр}$ =119.74-119.44=0.3мм=300 microns;

$2Z_{\min 1}^{гр}$ =119.44-114.03=5.41мм=5410 microns.

$Z_{\max 4}^{гр}$ =119.94-119.8=0.14=140 microns;

$Z_{\max 3}^{гр}$ =119.8-119.52=0.28=280 microns;

$Z_{\max 2}^{гр}$ =119.52-118.9=062=620 microns;

$Z_{\max 1}^{гр}$ =118.9-172.03=6.87=6870 microns.

Based on the data obtained, we build a diagram of the graphical placement of allowances and tolerances

General allowances $Z_{\min}^{заг}$ and $Z_{\max}^{заг}$ is obtained by adding intermediate allowances:

$2Z_{\min}^{заг} = 5410 + 300 + 200 + 40 = 5950$ microns;

$$2Z_{\max}^{заг} = 6870 + 620 + 280 + 140 = 7910 \text{ microns;}$$

Total nominal allowance:

$$2Z_{заг}^{ном} = 5950 + 1000 - 40 = 6910 \text{ microns;}$$

$$d_{ном} = 120 - 6.9 = 113.1 \text{ мм;}$$

For all other treated surfaces, we find the allowances in the table method and enter the values in the table 3.5

Table 3.5 - Values of allowances for processing

№ Of surface	Size	The allowance, mm		Tolerance, mm
		Tabular	Calculated	
1	2	3	4	5
1	Ø 120	-	$2 \cdot 3{,}45$	± 1.0
2	Ø90	$2 \cdot 40$	-	± 1.0
3	20	4,0	-	± 0.5
4	146	4,0	-	± 1.0
5	58,5	4,0	-	± 0.8
6	77,5	4,0	-	± 0.8
7	Ø158	$2 \cdot 4{,}0$	-	± 1.0
8	180	4,0	-	± 1.0

We check the correctness of the calculations:

$$Z_{\max 4}^{гр} - Z_{\min 4}^{гр} = 140 - 40 = 100 \text{, microns}$$

$$\delta_3 - \delta_4 = 140 - 40 = 100 \text{, microns;}$$

$$Z_{\max 3}^{гр} - Z_{\min 3}^{гр} = 230 - 220 = 80 \text{ microns;}$$

$$\delta_2 - \delta_3 = 220 - 140 = 80 \text{, microns;}$$

$$Z_{\max 2}^{гр} - Z_{\min 2}^{гр} = 620 - 300 = 320 \text{ microns;}$$

$$\delta_1 - \delta_2 = 540 - 220 = 320 \text{ microns;}$$

$$Z_{\max 1}^{гр} - Z_{\min 1}^{гр} = 6870 - 5410 = 1460 \text{ microns;}$$

$$\delta_з - \delta_1 = 2000 - 540 = 1460$$ microns.

3.3Determining the amount of equipment

Let's calculate the cutting modes for the operation 025 vertically drilling.

Drill 4 holes at a time Ø6.7+0.1 to a depth of 16mm with simultaneous chamfering 1×45o.

The machine type is vertical - boring. The tool - drill with a cylindrical shank, step for simultaneous removal of a facet and drilling of a hole under a carving M8 ГОСТ 2И21-1-86 [2]

Cutting depth t = 3.35mm .

According to table 25 (p. 227 [2] vol. II) denote the feed S = 0.28mm / rev.

Cutting speed at drilling is calculated by the formula:

$$V = \frac{C_V \cdot D^g}{T^m \cdot S_z^y} \cdot K_V , \qquad (3.8)$$

According to the [2] we define: Cv =21.8; q=0,25; y=0,55; m = 0,125.

The period of stability of the drill T = 35 min.

Overall cutting ratio:

$$K_V = K_{iV} \cdot K_{MV} \cdot K_{lV} = 0.89 \cdot 1 \cdot 1 = 0.89$$

$$K_{MV} = \left(\frac{150}{163}\right)^{1.3} = 0.89$$

$$K_{iV} = 1.0$$

$$K_{lV} = 1.0$$

$$V = \frac{21.8 \cdot 6.7^{0.25}}{35^{0.125} \cdot 0.28^{0.55}} \cdot 0.89 = 20 m/\min$$

the speed of the tool is calculated by the formula:

$$n = \frac{1000 \cdot V}{\pi \cdot d} = \frac{1000 \cdot 20}{3.14 \cdot 6.7} = 850 \text{ rpm.}$$

Torque is calculated:

$$M_{кр} = 10C_{м} \cdot D^{g} \cdot S^{y} \cdot K_{p} = 10 \cdot 0.021 \cdot 6.7^{2} \cdot 0.28^{0.8} \cdot 1.03 = 3.5 \text{ Hm}.$$

$$C_{M} = 0.021;``g = 2.0;\quad y = 0.8;``K_{p} = 1.03.$$

Axial force:

$$P_{o} = 10C_{p} \cdot D^{g} \cdot S^{y} \cdot K_{p}$$

$C_{p} = 42.7;``g = 1.0;``y = 0.8.$

$$P_{o} = 10 \cdot 42.7 \cdot 6.7^{1.0} \cdot 0.28^{0.8} \cdot 1.03 = 1064 \text{ H}$$

Cutting power:

$$N_{різ} = \frac{M_{кр} \cdot n}{9750} = \frac{3.5 \cdot 850}{9750} = 0.3 \text{ kW} \qquad (3.9)$$

Power for the drilling head:

$N_{різ.г.} = 0{,}3 \cdot 4 = 1.2$ kW

Drive power:

$N_{пр} = \frac{1.2}{0.85} = 1.41$ kW.

We accept vertical - drilling machine model 2A150. engine power 4.5 kW.

The results of the choice of cutting modes for all other operations [7] are given in the table 3.6.

Table 3.6 - Cutting modes

№ operation	The name of the operation	Machine type	Cutting depth t, mm	Cutting modes are adjusted					
				S, mm / rev	V, m / min	n, min.$^{-1}$.	P, H	$N_{різ}$, kW	$N_{пр}$, kW
1	2	3	4	5	6	7	8	9	10
005	Turning 1. Cut the end face Ø125 to Ø90	Mod. 1283 $N_{дв}$=12	3	0.24	101.6	259	858	1.42	1.67
	2. Cut the end face Ø275 to Ø158		3	0.8	80	149	139	1.82	2.1
	2\`. Cut the ledge Ø158 for L=13		2	0.24	111	224	572	1.03	1.22
	3. Cut end Ø275 to Ø164.		1	0.8	103.5	194	104	1.7	20
	4. Drill a hole to Ø86		3	0.16	102.6	380	772.8	1.29	1.52
	5. Drill a hole to Ø89.3		1.6	0.24	62.8	224	565	0.58	0.68
	6. Remove the facet 1×45		1.7	0.24	62.8	224	565	0.58	0.68
	7. Counterbore hole to Ø89.8		0.2	0.38	42.2	150	-	0.1	0.11
	8. Counterbore hole to $Ø90^{-0.024}_{-0.054}$		0.1	0.24	63.3	224	-	0.045	0.05
010	Turning . 1 Cut the end face	Mod. 1284 $N_{дв}$=27 kW	4	0.8	122	194	324	5.5	6.4
	2. Cut the end face fom Ø145 to Ø120		3	0.8	93.5	149	280	3.1	3.7
	3. Cut the end face fom Ø275 to Ø197		3	0.8	93.5	149	280	4.2	5.0
	4. Cut the end face fom Ø145 to Ø120		1	0.8	88	194	106	1.52	1.8

Continuation of Table 3.6.

020	Aggregate - drilling 1. Drill 6 holes at a time Ø20	2Г175 $N_{дв}$=7.5kW	10	0.21	22.6	360	243	0.9	1.0
	2. Mill 6 holesØ21.5 remove the facet		0.75	0.38	30.3	450	412	2.0	2.4
	3. Ream out 6 holes simultaneously Ø22 by one pass		0.25	0.78	25	310	-	-	-
025	Vertically drilling 1. Drill 4 holes Ø6.7 while removing the chamfer	2A150 N=4.5 kW	3.35	0.24	21.8	860	-	1.18	4
030	Vertically drilling Cut the thread M8×1.25 in 4 holes. at L = 12mm	2A150N=4.5 kW	1.2	1.25	3.7	147	-	3.36	4

3.4 Design of special equipment and tools

Establishing the process of designing the process of processing parts, at the same time specify which machine will perform a particular operation. The choice of the type of machine is primarily determined by the ability to meet the technical requirements, with respect to the accuracy of its size, shape and cleanliness of surfaces, as well as the conformity of the basic dimensions of the machine with the overall dimensions of the workpiece, the least time consuming processing.

In accordance with the foregoing, we accept the following equipment to carry out the design process:

Lathe semi-automatic machines mod. 1B284;

Lathe semi-automatic machines mod. 1283;

Vertical - drilling machine mod.2H150;

Aggregate - boring machine tools mod.2Г175.

As tools we use the standard cutting tool, the most targeted use of which. The cutting tool must have high cutting resistance, with high cutting modes and high dimensional resistance. The hub is a cast iron casting for which we use the cutting tool with hard alloy plates Bx 8 (tungsten - cobalt alloy).

The use of a cutting tool equipped with Bx 8 alloy allows for machining at high cutting modes, resulting in reduced machine time.

Selection and justification of the principle of action, structural scheme. Based on the conditions of productivity on turning and drilling operations, we accept for a turning operation a single device with a clamp; for drilling operation - four-spindle drilling head with mechanical workpiece clamp. Consider our choice and justification of the principle of structural diagrams. Let's carry out a structural analysis and synthesis of the arrangements for the device, outline three options for the implementation of this device. To choose the best option, we determine the stock factor for each scheme by the formula:

$$K = K_0 \cdot K_1 \cdot K_2 \cdot K_3 \cdot K_4 \cdot K_5 \cdot K_6, \qquad (3.10)$$

where K_0 - geometric reserve ratio, K_0=1.5

K_1 - a factor that takes into account the increase in forces due to random inequalities;

K_2 - coefficient that calculates the increase in cutting forces due to blunting of the tool;

K_3 - coefficient that calculates the increase in forces with uneven turning;

K_4 - coefficient characterizing the constancy of the clamping force;

K_5 - coefficient characterizing ergonomics;

K_6 - coefficient that calculates the torque.

The value of the coefficient is determined by the literature [5]. For variant with eccentric clamp:

For version with cam clip

$$K = 1.5 \cdot 1.2 \cdot 1.2 \cdot 1.2 \cdot 1 \cdot 1.0 \cdot 0.6 = 1.3$$

For option with clamp using paws

$$K = 1.5 \cdot 1.2 \cdot 1.2 \cdot 1.2 \cdot 1 \cdot 1.0 \cdot 1.5 = 3.9$$

The above calculations show that the third option is the most reliable.

Using the same formula, we determine the stock factor for the drill head:

$$K = 1.5 \cdot 1.0 \cdot 1.2 \cdot 1.0 \cdot 1 \cdot 1.0 \cdot 1.5 = 2.7$$

As can be seen from the calculations, the factor of the stock provides a secure fixing of the workpiece during processing.

Power calculation of drive parameters. Calculation of clamping force for a lathe. This device handles the end face of the workpiece and the hole Ø90.

Surface data can be machined by installing the workpiece on the outer surface, ie in a three-chuck cartridge, you can also install the workpiece into a collet chuck on the surface machined on a smooth finger with a clamp on the plane.

Considering the technical requirements of the drawing it can be concluded that in this case it is advisable to use the scheme of installation of the workpiece on a smooth finger and plane. For fast and reliable clamping of a part we use a pneumatic clamp.

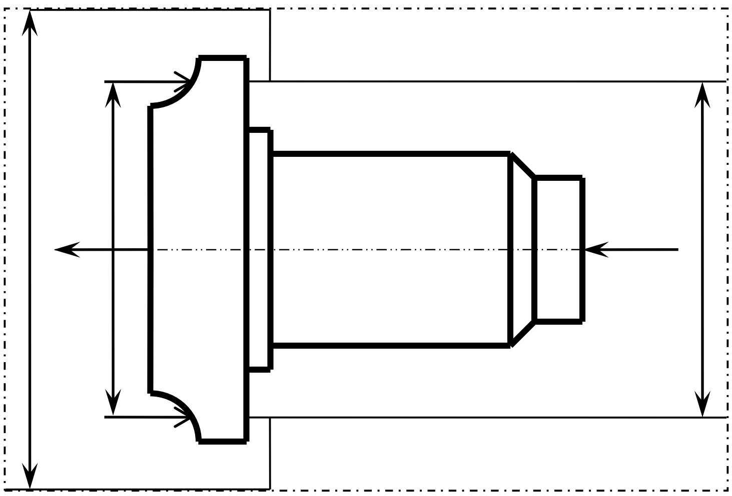

Figure 3.2 -Scheme of workpiece clamp

From the above calculations for this operation, we determine that the greatest cutting force occurs during machining of the end and Pz = 858kg.

Determine the torque acting on the workpiece as a result of force Pz.

$$\mathrm{M} = \frac{\mathrm{Pz} \cdot D}{2} = \frac{8580 \cdot 120}{2 \cdot 1000} = 514{,}8 \text{ Nm}, \tag{3.11}$$

Axial force from previous calculations P=6700H

The clamping force is determined by the formula:

$$\mathrm{P}з = \frac{2 \cdot км - f_1 \cdot PD_{оп}}{f_2 \cdot D_{пр} + f_1 \cdot D_{оп}}, \tag{3.12}$$

where $D_{оп}$ and $D_{пр}$ - diameters of supports and grips of the device (we accept constructively).

f_1 - the coefficient of friction at the point of contact of the workpiece with the supports, f_1=0.16 [2]p.85 table 10;

$к$ - stock factor, $к$=3.9

$$\mathrm{P}з = \frac{2 \cdot 3{,}9 \cdot 514{,}8 - 0{,}16 \cdot 6700 \cdot 0{,}23}{0{,}4 \cdot 0{,}24 + 0{,}16 \cdot 0{,}23} = 28380 \text{ H}.$$

Determine the diameter of the foam cylinder to secure the part:

Pressure $\mathrm{P}n$=6 kg / cm ^{2}.

Required cylinder area:

$$S = \frac{Q}{Pn} = \frac{2838}{6} = 473 \text{ cm}^2, \tag{3.13}$$

The diameter of the cylinder:

$$D = \sqrt{\frac{4S}{\pi}} = \sqrt{\frac{4 \cdot 473}{3.14}} = 24.2 \text{ cm}, \tag{3.13}$$

Accept = 250mm.

Calculation of clamping force for drilling operation**.**

From the above calculations for this operation the torque is:

$$\mathrm{M}_{КР} = 3.5 \text{ Nm}.$$

Axial cutting force:

$$P_o = 1064 \text{ H.}$$

The clamping force is calculated by the force of friction:

$$\text{M}_{KP} = F_T \cdot r, \tag{3.14}$$

where r – radius of friction force application, m.

F_T – friction force, H.

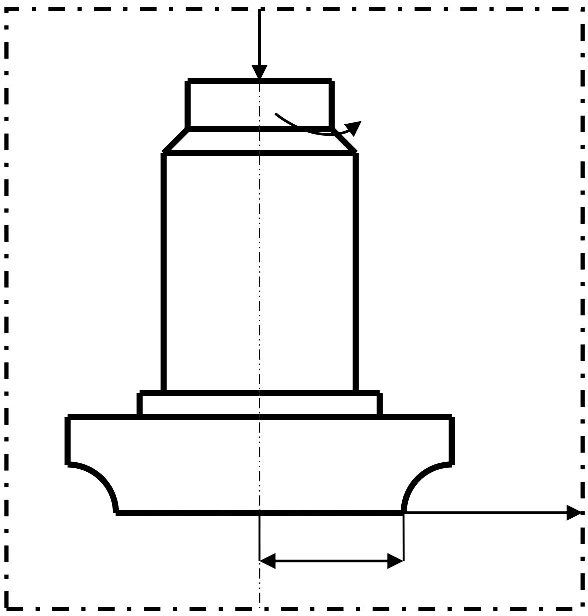

Figure 3.3 - Cutting forces

$$F_T = P_З \cdot f, \tag{3.11}$$

where $P_З$ – clamping force, H.

f – coefficient of friction, $f = 0.12$.

$$\text{M}_{KP} = P_З \cdot f \cdot r. \tag{3.12}$$

From here

$$P_З = \frac{\text{M}_{KP}}{f \cdot r} = \frac{3.5}{0.12 \cdot 0.07} = 417 \text{H.} \tag{3.13}$$

This clamping force is provided by two springs that clamp the part through the conductor plate.

The most loaded link in our device is the clamping paws. Let's calculate the paws on the bend.

The highest stresses occur in the section with the coordinate 45mm. We determine the moment of bending in this section:

$M_{ЗГ} = Q_2 \cdot 45 = 1419 \cdot 45 = 63855$ kgmm.

The stresses arising in the specified cross section are determined by the formula:

$$\sigma = \frac{M_{ЗГ}}{W} = \frac{63855}{1875} = 34 \text{ kg / mm}^2, \quad (3.14)$$

where W - is the moment of inertia.

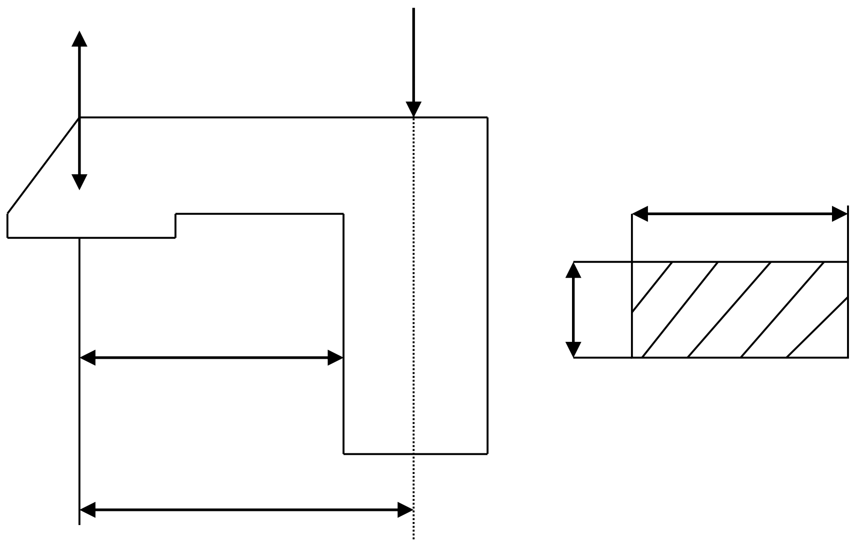

Figure 3.4 - Scheme of loads

$$W = \frac{h \cdot b^2}{6} = \frac{50 \cdot 15^2}{6} = 1875 \text{mm}^2, \quad (3.15)$$

Tensile strength for steel 30[σ]=50kg / mm^2, that is, the selected profile provides strength conditions.

σ=34кг/мм^2 <[σ]=50kg / mm^2.

For the drilling head we will calculate the working spindle for torsion in the cross section from the efficiency of the spindle.

$$\tau_{KP} \le [\tau_{KP}], \quad (3.16)$$

Estimated value of torsional stress:

$$\tau_{KP} = \frac{M_{KP}}{W_{KP}}, \quad (3.17)$$

where $M_{KP} = 3{,}5$ Нм- torque, we accept from the previous calculations;

W_{KP} – torque resistance.

$$W_{KP} = \frac{\pi \cdot d^3}{32}, \quad (3.18)$$

We have

$$\tau_{KP} = \frac{32M_{KP}}{\pi d^3} = \frac{32 \cdot 3.5 \cdot 10^3}{3.14 \cdot 12^3} = 20.6 \text{ kg / mm}^2.$$

Calculation of adjustments for accuracy. Calculation of lathe. With the workpiece base layout selected, the inaccuracy will be due to the gap between the finger and the workpiece inner opening.

Workpiece diameter: $D_{ЗАГ} = 120^{-0,024}_{-0,059}$;

We take the diameter of the finger constructively: $d = 120^{-0.064}_{-0.084}$;

Base error will be:

$\varepsilon_\delta = D_{\max} - d_{\min} = 119.976 - 119.918 = 0.068$ mm

Such a basis provides the requirement of the drawing that the radial beating of cylindrical surfaces, which should not exceed 0,12 mm.

Then the error of the installation will be equal:

$$\varepsilon_y = \sqrt{\varepsilon_\delta^2 + \varepsilon_з^2} \text{ mm}, \quad (3.19)$$

$$\varepsilon_\delta = 2\Delta + \delta_1 + \delta_2 \text{ mm}, \quad (3.20)$$

where Δ - minimum clearance, Δ=0,02 mm;

δ_1 - tolerance on the diameter of the hole, δ_1=0,21 mm;

δ_2 - tolerance on the diameter of the finger, δ_2=0,02 mm.

$$\varepsilon_\delta = 2 \cdot 0.02 + 0.02 + 0.21 = 0.27 \text{ mm}.$$

$\varepsilon_з$=180 microns =0,18 mm.

$$\varepsilon_y = \sqrt{0,027^2 + 0,18^2} = 0,02 \text{ mm}$$

$$\varepsilon_\Sigma = \frac{1}{K}\sqrt{(K_1 \cdot \varepsilon_y)^2 + (K_2 \cdot \varepsilon_{уд})^2 + (K_3 \cdot \varepsilon_n)^2 + (K_4 \cdot \varepsilon_{рп})^2 + K_5\Sigma\varepsilon_{вр} + K_6\Sigma\varepsilon_6} \text{ mm}, \quad (3.21)$$

$$\varepsilon_\Sigma = \sqrt{0.85^2 + 0.03^2 + 0.0053^2 + 0^2 + 0.02 + 0.34} = 0.778 \text{ mm}.$$

In this case, the workpiece is based on the device on the finger and end, that is, similar to the device on the turning operation. Therefore, the inaccuracy of the installation will be the same as that of the lathe operation.

In the above calculations, the base error is ε_{δ}=0, 068mm. And the installation error ε_{y}=0,02 mm.

This layout scheme provides the required accuracy when drilling holes Ø6,7 mm.

General description of the design, principle of operation. Designed by turning the device used in the operation 005 in turning the hub. The workpiece is mounted on a finger surface Ø120 mm and the end of the flange on the support. The workpiece clamp is made by means of a pneumatic cylinder. When the air is fed into the rod cavity, the piston moves down and entails the stem. The rod in turn moves the rocker arm down. The rocker arm is pivotally connected to the clamping paws that clamp the workpiece to the support. In the sleeve of the clamping paw at an angle, a groove is made, and a lock is tightened in the housing. When the paws are moved down, it simultaneously rotates relative to its axis by 90^{o}. To remove the part from the device, the air is fed into the piston cavity. The rod moves the rocker arm up. Accordingly, moving up the paws securing the part and at the same time rotate 90o. thus, the part is released from the grips and can be removed from the device.

Drilling head.

The designed drilling head is used for vertically drilling operations for drilling four Ø6.7 mm holes at a time. M8.

The head is mounted in the spindle of the drilling machine on the Morse cone. Torque from the machine spindle is transmitted to the spindle of the head on which the gear with internal teeth is planted. The teeth of this gear engage with small gears, which in turn are fixed to the working spindles. At the ends of the working spindles are the expansion sleeves in which the drills are attached. On both sides of the head are marked with two guide rollers, on which the conductor plate moves. When lowering the drill head down, the rollers come into the holes of the stand, and the conductor plate clamps the workpiece to the stand. With further lowering of the drill head, the drill bit begins to drill holes.

Special cutting tool calculation. In the designed technological process, it treats different surfaces. The following tools are used: cutters, drills, countersinks, sweeps, taps. This technological process does not require the use of a special tool. Therefore, all operations use a cutting tool standard made according to ГОСТ on it and which does not require additional calculations.

The degree of capture of workers by mechanical labor:

$$C_M = \frac{P_M}{P} \cdot 100\%, \tag{3.21}$$

where P_M – number of workers performing mechanical work;

P – the total number of workers in the shop.

$$C_M = \frac{13}{40} \cdot 100 = 0.325 \cdot 100 = 32.5$$

The level of mechanized labor in total labor costs:

$$Y_{M.T} = \frac{P_a \cdot K}{P} \cdot 100\%, \tag{3.22}$$

where P_a – the number of workers (in all shifts) at the site engaged in mechanized labor;

K – coefficient of mechanization when working on machines and other equipment, covering the time of mechanized labor to the total time spent.

$$Y_{M.T} = \frac{30 \cdot 0.8}{40} 100 = 60.$$

Spindle node calculation. Strength calculation

Check the safety margin n at alternating voltages by the formula 3.23:

$$n = \frac{(1 - r^4) \times d^3 \times \sigma_{-1}}{10 \times \sqrt{(a \times M)^2 + (a_K \times M_K)^2}}, \tag{3.23}$$

where d = 48 mm is the outer diameter of the spindle;

$\sum = 0$, since the spindle is solid;

Spindle material is steel 40X;

Heat treatment - hardening with tempering to 40…50 HRC;

$\sigma_{-1} = 260\ Н/мм^2$;

M = 0 – bending moment;

$M_{кр} = 685\ Н \times м$, (see choice of engine);

$\sigma_Т = 720\ Н/мм^2$;

Substitute the obtained data into the formula:

$$n = \frac{(1 - 0{,}019^4) \times 48^3 \times 260}{10 \times \sqrt{(0{,}65 \times 685)^2}} = 6500$$

For the strength reserve usually take the value n = 1,3… 1,5. Since, n = 6500, the strength of the spindle is ensured.

Calculation of the specific pressure. Check the spline section for specific pressures. To calculate, we use the formula 3.24:

$$P = \frac{8 \times M_k}{(D^2 - d^2) \times L \times z \times \psi}, \quad (3.24)$$

where $M_k = 685\ Н \times м$;

D = 48 mm, d = 44 mm is the inner diameter of the slots;

L = 358 mm - length of the slot section;

z = 8 – number of slots;

ψ = 0,75 – coefficient of uneven use of the work surface;

Substitute the obtained data into the formula:

$$P = \frac{8 \times 685 \times 1000}{(48^2 - 44^2) \times 358 \times 8 \times 0{,}75} = 6{,}9\ Н/мм^2$$

$P = 6{,}9 \le [P] = 10...20\ Н/мм^2$, [15] The condition is met, so the specific pressure strength is ensured.

There is no need to calculate the rigidity as the spindle is not fast-moving.

Bearing selection. To calculate, we use the formula 3.25:

$$C = 0{,}1 \times (h_{k\alpha} + m \times A) \times (n \times h)^{0{,}3} \times R_v \times R_t\,, \qquad (3.25)$$

where $R_v = 1{,}2$; $R_t = 1$; $h = 1050$ об/хв; $n = 5000$год; $m = 1$;

Substitute the obtained data into the formula 3.28:

$$C = 0{,}1 \times 0{,}5 \times 20000 \times (1050 \times 5000)^{0{,}3} \times 1{,}2 \times 1 = 46000\ H$$

According to the catalog we choose bearings:

Radial No. 310 for which [C] = 48500 H,

Stopping No. 8310 for which [C] = 56300 H

4.PROJECT PART

4.1 Determination of the main and auxiliary areas of the shop

The production area for the mechanical section is determined by the formula:

$$F_{вир} = Cp \cdot F_{верст} = 112 \cdot 20 = 2240\,\text{m}^2 \qquad (4.1)$$

where $F_{верст}$ *=15…25 m²* – for medium dimensions of the machine.

The assembly test site is determined by the formula:

$$F_{скл.випр.} = (30...40\%) \cdot F_{вир}, \qquad (4.2)$$

$$F_{скл.випр.} = 35\, від\ 2240 = 784\ m^2$$

Auxiliary offices:

а) tool sharpening;

$F_{заточ.}$ The department is selected from the dimensions of products manufactured in mechanical sections. For medium size products:

$$F_{заточ.відділ.} = 10...12 м^2 \text{ we will accept } 12\ m^2.$$

$$F_{заточ.відділ.} = 12 \cdot 7 = 84\ \text{m}^2.$$

б) repair base;

When counting $F_{ЦРБ}$. based on the number of machines and the specific area under one machine, which is located in the CRH. By calculation Cp = 2 then

$F_{ЦРБ} = Cp \cdot F_{верст.} = 2 \cdot 20 = 40\ \text{m}^2$. (5,11)

в) repair of production equipment and tools;

The area of such branch is chosen proceeding from dimensions of products. For medium products $F_{р.в.о.}$*=22-24* m². on 1 machine.

We accept

$$F_{р.в.о.} = 24 \cdot 6 = 144\ \text{m}^2, \qquad (4.3)$$

г) control department;

at two alternating work in multiparty production two controllers are necessary.

$$F_{к.п} = P \cdot Fn \cdot Kк, \qquad (4.4)$$

where P- number of controllers;

F- area per controller $F=5\text{-}6\ m^2$.

$К_к$- coefficient that takes into account the increase in area for the location of control rooms.

$$F_{к.п} = 2 \cdot 6 \cdot 1.75 = 20\ \text{m}^2.$$

д) Composition of metal, blanks, parts, assemblies.

The area of metal compositions, workpieces is calculated by the formula:

$$S_I = \frac{A \cdot Q}{q \cdot k \cdot m} = \frac{4 \cdot 6000}{1.5 \cdot 0.6 \cdot 254} = 105\ \text{m}^2., \tag{4.5}$$

where A- storage time of blanks in a warehouse for mass production A=3-6 днів and storage time of parts and assemblies 6-12 days;

q– allowable load ($q = 1.5$ t/ m^2);

$к$– the utilization factor of the area, taking into account the aisles and passages, $к$ =0,5-0,65 ;

m– number of working days per year.

$$S_{II} = \frac{A \cdot Q}{q \cdot k \cdot m} = \frac{7 \cdot 10000}{1.5 \cdot 0.6 \cdot 254} = 306\ \text{m}^2., \tag{4.6}$$

The total area is:

$$S = S_I + S_{II} = 105 + 306 = 411\ \text{m}^2\ , \tag{4.7}$$

ж) Premises ZOR and chip processing.

The area is determined based on the cost of lubricants and is calculated by the formula:

$$Q_M = \frac{q_M \cdot Cn \cdot 254}{1000}, \tag{4.8}$$

where q_M and q_E - consumption of lubricants and emulsions per 1 machine per day (kg);

Cn– the number of machines in the shop (pcs.);

$$Q_M = \frac{0.2 \cdot 112 \cdot 254}{1000} = 0.57\ \text{t/y};$$

Emulsion costs:

$$Q_M = \frac{2.0 \cdot 112 \cdot 254}{1000} = 5.7 \text{ t/y.}$$

The area of the chip processing room is set from the condition 1m^3 calculation of the area per unit of technological equipment of the mechanical shop.

$$F_{зор.п.стр} = Cp \cdot 1\text{м}^2 = 112*1 = 112\text{m}^3 \quad (4.9)$$

з) The total area of auxiliary offices is the sum of their areas:

$$F_{заг.} = F_{зат.} + F_{ЦРБ} + F_{P,B,O} + F_{СКЛ} + F_{кв} + F_{зор.п.стр}, \quad (4.10)$$

$$F_{заг.} = 84 + 40 + 144 + 20 + 411 + 112 = 811 \text{ m}^2.$$

е) Office - domestic premises.

The area of administrative and office premises is calculated 4m^2 per ITR, and their number is taken in the range of 7-10% of the number of key workers. The number of ILOs is 1-2% of the number of ITR, then from 224 people of the main workers at the rate of 8% we get 18 people. ITR. From 18 people. ITR - 2 people. MOP, a total of 20 people. For which the total area of the premises will be:

$$F_{С.П.П} = F \cdot F_{пит} = 20 \cdot 4 = 80 \text{ m}^2, \quad (4.11)$$

The area under the rest area is 0,9m^2 per employee:

$$F_{B.K} = (224 + 20) \cdot 0{,}9 = 219{,}6 \text{ m}^2., \quad (4.12)$$

The area under the buffet is chosen at the rate 1m^2 area per employee while it is considered that in the first shift works no more than 112 people, then

$$F_б = 90 \cdot 1{,}0 = 90 \text{ m}^2$$

The area of sanitary and hygienic rooms (medical center, locker rooms, showers, toilets, washbasins) we choose 0,9 m^2 з calculation when the shop employs more than 100 people:

$$F_{С.Т.П} = 150 \cdot 0.9 = 135 \text{ m}^2 \quad (4.13)$$

The total area of office space is:

$$F_{заг.} = F_{с.п.т.} + F_{в.к.} + F_{б.} + F_{с.т.п.}, \quad (4.14)$$

$$F = 80 + 219.6 + 90 + 135 = 524.6\text{m}^2$$

к) The total area of the mechanical assembly shop

$$F_{заг} = F_{вир.пл.} + F_{доб.в}, \quad (4.15)$$

$$F_{заг} = 3024 + 811 = 3835\,\text{m}^2.$$

4.2 Development of plans for the layout of the shop and placement of equipment on the site

Development of the composed scheme of the mechanical assembly shop, calculation of its area and the technological plan of a site of mechanical processing

Output data:

- the total number of machines of the shop C_p-112 pcs.
- mechanical section $C_{p.m}$-16 pcs.
- number of sharpening machines $C_{p.з}$-7 pcs.
- number of CRH machines $C_{p.ц.б}$-2 pcs.
- the number of machines for repairing equipment and tools $C_{p.c.m}$-6 pcs.
- dimensions of all machines - average.
- type of production - large-scale.
- product weight К 020.68.43 – 125 kg.

Buildings of the mechanical assembly shop:

- A rectangular room with dimensions of width and length 1:2;

- Grid of columns 12×18m;

- The height of the shop – 7,2m;

- Number of passages - one main and two transverse.

Auxiliary compartments will be located along the spans of the wall columns. The warehouse is located perpendicular to the longitudinal columns on the end side of the shop.

The layout of the production departments of the shop for multi-series production of the organizational form of work is made in accordance with the developed technological process of machining the product К 020.68.43 hub.

The layout of the vehicles is related to the type of production according to the manufacturing process of the product.

As a vehicle, a conveyor has been selected for servicing metalworking machines, which will be located along the selected route at the hub machining section К 020.68.43.

Its length:

$$L = C_p \cdot l_i , \qquad (4.16)$$

where l_i - the length of the i-th machine, taking into account the passages between them.

C_p - this is the number of machines.

$$L = 13 \cdot 3 = 39\,\text{m}.$$

this is the number of machines.

Then the area of the accepted shop:

$$F_{ц} = a \cdot b , \qquad (4.17)$$

$$F_{ц} = 54 \cdot 72 = 3888\,\text{m}^2$$

which is close to the estimated:

$$F_{розр.} = 3835\ \text{m}^2.$$

The dimensions of the shop are set based on the total estimated area of the shop based on the use of unified standard sections of the frame of the building in accordance with the recommendations [8]. In our case, for a crane-free shop, the grid of columns will be 18×18 m, for which the width of the shop will be: *18×3 = 54* and *12×6 = 72.*

5 OCCUPATIONAL HEALTH AND SAFETY IN EMERGENCIES

5.1 Analysis of the production facility for which it is intended, in terms of occupational safety and environmental protection

The machining section of this part belongs to the main production facilities. Work on safety at the site is organized in accordance with the guidelines and rules for labor protection and safety.

For modern mechanical engineering is characterized by an increase in the speed of the working bodies of various equipment, machines and hand machines. It becomes difficult to balance the rotating masses. As a result, fluctuations occur, in some cases they are facilitated by harmful production factors that create adverse working conditions, such as vibration, accompanied by the operation of technological equipment, mechanical tools and vehicles.

Various machines and mechanisms are used in this mechanical shop. In the shop where the lathes are, there are such dangerous and harmful factors as: chips, dust, cutting tools, moving parts of the machine, as well as noise and vibration. Electric current is used to operate the machines. Technological processes are accompanied by the release into the air of industrial premises of harmful substances - vapors, solid and liquid particles. The use of lubricating and cooling liquids in the processing of parts is accompanied by the release of lubricating aerosols into the air, and in the processing of fragile parts dust is released, so it is necessary to use ventilation to remove harmful substances and purify the air. The machines use lubricants to lubricate moving parts, so care must be taken to prevent leakage and contact with the floor of the area where the equipment is located, as this will lead to contamination of soils and water bodies.

5.2 Protection on removal of metal dust from zones of processing and decrease in dustiness of air in production rooms

After analysis and identification of deficiencies in order to improve working conditions, we use in addition to general exchange ventilation, which gives little effect, local ventilation. Local ventilation allows you to completely eliminate dust in the room.

Pneumatic vehicles provide the most complete removal of chips from the processing area. Which are equipped with current collectors and which allow to remove chips, dust to other harmful technical wastes directly from the cutting tools.

The task of removing dust and chips from the cutting tool when performing operational work is solved simply. For example, the sawdust receiver is shown in the form of a pipe attached to the lathe holder and connected to the suction equipment by means of a flexible metal sleeve.

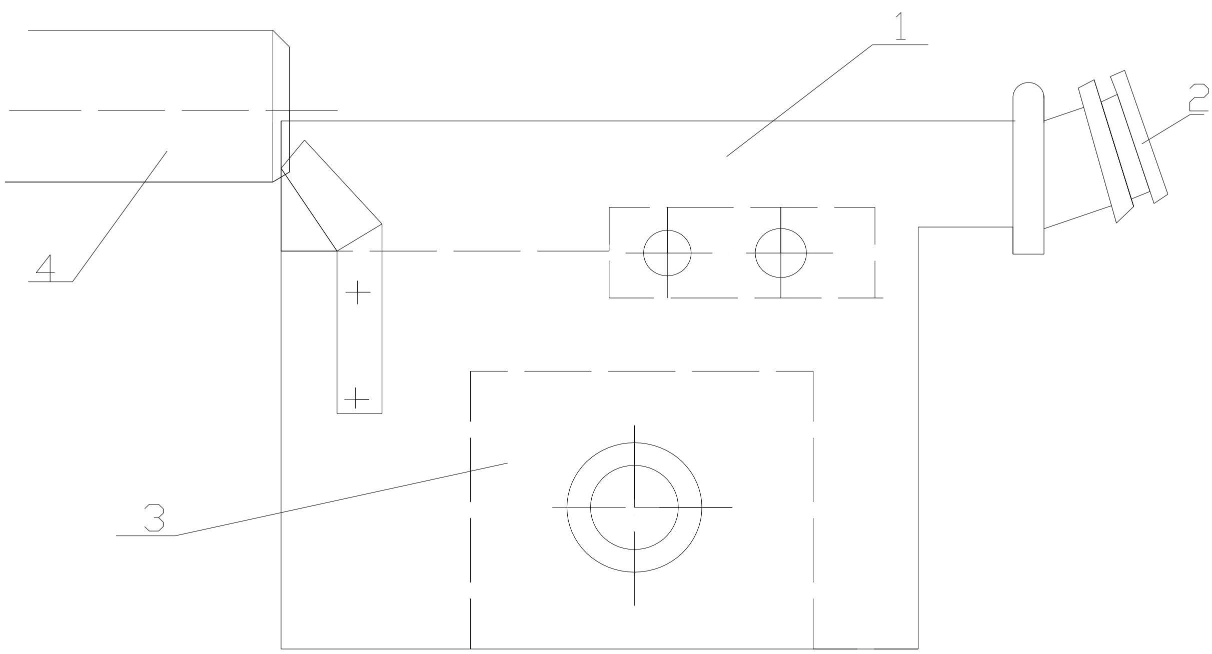

Figure 5.1 - Sawdust receiver.

1- metal case; 2- metal sleeve; 3- cutter holder; 4- blank

Removal of dust and shavings from drilling machines is carried out by means of a dust chip receiver which design is shown in Fig.5.2

Effective operation of such suckers is achieved at the following geometric dimensions:

$$H=1.2d;$$

$$\ell=(3...4)d;$$

$$h=1.5...2\ mm;$$

$$d_1=d_2=1.1d.$$

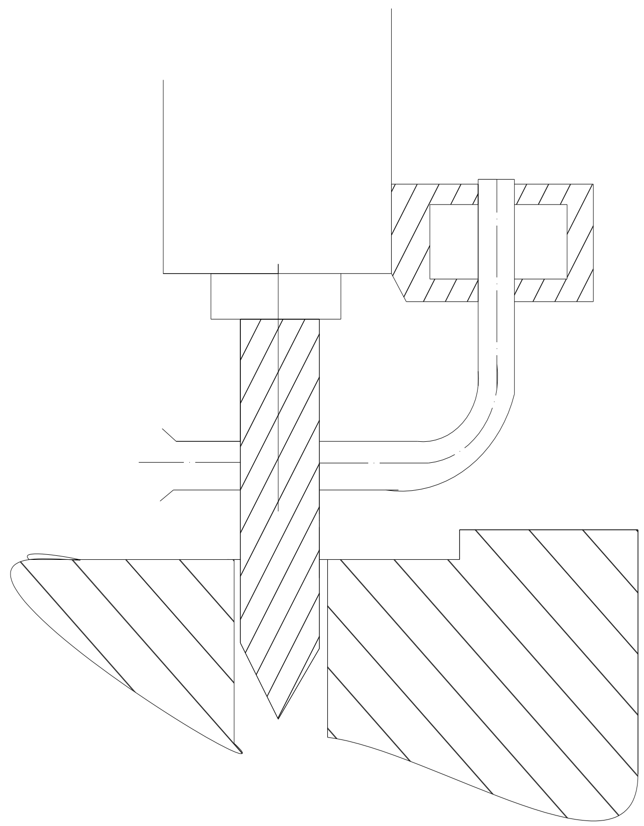

Figure 5.2 = Sawdust receiver for a drilling machine

5.3 Planning and accounting for on-site CA training

Due attention should be paid to the planning and accounting of CO training at the business site.

The guiding documents according to which the training with the CA is organized at the facility are:

- order of the head of the district (city) central office based on the results of preparation for the last year and tasks for the new school year;
- CO training and education programs;
- extract from the acquisition of CO courses and training institutions.

According to these documents, the following are being developed at the facility:

- order of the head of the CO of the object based on the results of training with the CO for the last and tasks for the new school year The following are attached to the order:
- list of study groups;
- list of topics of exercises and trainings with CO;
- topics for the preparation of CO;
- training plan for management, non-military formations, workers and employees of the facility;
- class schedule for each study group.

In addition, the following can be developed at the facility:

- schedule of use of educational material base;

Accounting for training and education with CO on site is ongoing. Accounting documents at the facility include:

- logbook of classes with CO;
- journal of command and control staff training at CO courses and advanced training institutions.

After studying the theoretical part, it is necessary to consolidate the knowledge gained during various trainings and exercises.

Thus, the determining factor in the planning of civil defense activities at the objects of economic activity is the direct preparation of the plan of the CO of the object - a document that defines the tasks and timing of measures with the CO. It is intended for the facility's chief, staff and services as a guide to action. The implementation of the plan ensures the achievement of the main task of the Central Office - the maximum reduction of human losses and destruction in any difficult situation. It reflects the specific ways and means to achieve this goal not only in wartime, but also in natural disasters and large-scale industrial accidents.

CONCLUSIONS

As a result of solving the problems submitted for the diploma project, the following is fulfilled:

the current workpiece manufacturing option is analyzed, the shortcomings identified and the ways of their elimination are indicated;

- a new more accurate and material-based workpiece of the detail is proposed;
- the structural analysis of possible variants of technological process of manufacturing a part is carried out, the optimum cost option is selected;
- for the new variant of the workpiece the values of the total and intermediate allowances of the operational sizes were calculated, the dimensional analysis of the new variant of the technological process was carried out;
- cutting modes, timing and operational machining are defined for the new TP;
- new technological equipment (lathe, drill head, supports) is selected).

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