Ministry of Education and Science of Ukraine
Ternopil Ivan Pul'uj National Technical University
(full name of higher education institution)
Engineering of Machines, Structures and Technologies
(faculty name)
Mechanical Engineering Technologies
(full name of department)

EXPLANATORY NOTE

for diploma project (thesis)

bachelor
(educational-proficiency level)

topic: **Improving the technological process of machining part "body" 714252.004**

Submitted by: fourth year student group IMP-42

Specialism (field of study)

131 «Applied Mechanics»
(code and name of specialism (field of study))

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Ternopil
2022

Ministry of Education and Science of Ukraine
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Faculty *Engineering of Machines, Structures and Technologies*
Department *Mechanical Engineering Technologies*
Educational degree *Bachelor*
Field of study *131 Applied Mechanics*
(code and title)
Specialism
(code and title)

APPROVED BY
Head of Department *Assoc. Prof., Okipnyi I.B.*

Assignment

FOR QUALIFICATION PAPER (THESIS) FOR STUDENT

Ramesh Siddiq Roshan
(SURNAME, NAME, PATRONYMIC)

1. Project (thesis) theme. **Improving the technological process of machining part "body" 714252.004**

Project (thesis) supervisor *Prof., Vasylkiv V.V.*
(SURNAME, NAME, PATRONYMIC, scientific degree, academic rank)

1.Approved by university order as *31.12.2021 № 4/7-1178*
2. Student's project (thesis) submission deadline *24 th of June 2022*
3. Project (thesis) design basis *Drawing of the part.*
Basic technological process. Annual production program.

4. Contents of engineering analysis (list of issues to be developed)
General-technical chapter. Analysis of part design and basic technological process of its manufacture.
Technological chapter. The choice of method of manufacture of the workpiece. Development of operational technological process. The calculation of the cutting conditions. Rate setting of operations.
Designing chapter. Choice and design description of attachments. Tools, materials and appliances for the manufacture of the case.
Safety measures.

5. List of graphic material (with exact number of required drawings, slides)
Body, body (workpiece), caliper gage – A1.
Routing technological process of of manufacturing part – A1, A2.
Job setting using the screw-turning and vertical milling operations –2A2.
Dual-stage face mill, dual-stage body – 2A3.
Hop traveler for multi-axis operation – A1.
Fixture for drilling holes of different diameters - A1.

6. Advisors of design (thesis) chapters

Chapter	Advisor's surname, initials and position	Signature, date	
		assignment given	assignment accepted
Safety measures	*Professor Valery Lazariuk*		

7. Date of receiving the assignment *25 th of June 2022*

PROJECT TIME SCHEDULE

LN	Diploma project (thesis) stages	Project (thesis) stages deadlines	Notes
1	*General-technical chapter*	*16.05.2022*	
2	*Technological chapter*	*7.06.2022*	
3	*Designing chapter*	*14.06.2022*	
4	*Safety measures*	*28.06.2022*	
5	*Drawings*	*4.07.2022*	

Student ____________ *Ramesh Siddiq Roshan*
(signature) (surname and initials)

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

ABSTRACT

The goal of the diploma project on the topic "Improving the technological process of machining part "body" 714252.004" is to consolidate practical skills in solving problems related to the development of technological processes of mechanical processing of parts, designing the necessary technological equipment, developing labor protection measures and justifying the feasibility of technical decisions.

In the general technical chapter the issues of product analysis, its purpose, the characteristics of a possible production option, the conclusions and the resolution of the task for diploma design are developed.

In the technological chapter the substantiation of the established type of production concerning the set production program is resulted, variants of technological process of manufacturing of the case are offered. The optimal technology is developed on the basis of the analysis of technological properties and basic possibilities of a part. The forces of fastening of the workpiece have been calculated, and the calculations of the part for durability are given. The trajectories of the cutting tool movement on machining operations are described and presented. Drawned and calculated dimensional chain and disposition scheme of allowances and tolerances for processing treated surfaces.

Design chapter includes operating principles of the selected devices, the design of special machine and tools for boring operation, and controlling devices for milling cutting are calculated. The power drive is calculated, and the design of the cutting and measuring tools has been carried out. Selected the method and scheme of control of parameters of the part. The developed designs of special machine tools made it possible to improve the quality of the part's manufacture and reduce the preparatory and final time in operations.

The adopted decisions ensured the possibility of concentration of operations, the organization of multi-machine service, production mobility, as well as a significant reduction of costs for equipping the production process.

CONTENTS

INTRODUCTION

The efficiency of production, its technical progress, and the quality of its products in many respects depends on the advance development of the production of new equipment, machines, machine tools and aggregates, from the production introduction of methods of technical and economic analysis, which will provide technical solutions and the economic efficiency of technical and structural developments.

The significance of setting all these issues in the preparation of the qualifications of the specialists in production is evident. In this regard, this diploma project consolidates, deepens and generalizes knowledge of the courses of modern technologies in mechanical engineering, progressive methods of manufacturing workpieces and their machining, design of equipment and cutting tools, computer-aided manufacturing subsystems and CAD information support for progressive technologies for obtaining the typical parts.

The main tasks of the modern industry are as follows: metal economy and productivity increase in mechanical processing, the establishment of certain regularities in the productivity and economy of technological processes of mechanical processing and assembly of machines and mechanisms.

The practical introduction of automation of manufacturing processes must transfer the implementation of a set of technological measures that create conditions for the product of economic methods and methods of production.

One of the main directions in mechanical engineering is the choice of optional forms of blanks, which give the least technological waste. Continuous increase of the precision of blanks and the approximation of their forms to the forms of finished parts sharply reduces the scope of different methods of cutting, restricts it in a number of cases, operations of finishing workpieces and thereby reducing the waste of metal in the shaping.

1. GENERAL-TECHNICAL CHAPTER

The purpose of this section - identify design flaws in the parts of statements contained in drawings and specifications, as well as examining possible to improve the manufacturability of the design.

1.1. The official purpose and characteristics of production facilities. Analysis of specifications.

This part "body" 714252.004 is designed for the assembly of intermediate bevel gear shafts that transmit force from the engine to the executing unit (longitudinal and transverse conveyor belt and screw-type, respectively). This unit is called - gear, which is the transmission mechanism of the machine. Drive gear through wedge-belt transmission and gear through the drive shaft is transmitted to another gear, which is directly linked to the executing unit.

To increase the transmission torque inserted into the body bearings and to reduce friction in the housing provided openings for filling and draining lubricant. Also, to prevent the occurrence of excessive oil pressure in the body cavity is provided for the breather hole, that is, the exhaust valve. To ensure the tightness of the case bearing caps are fixed on the skewer shaft seals. Also for mounting housing to the frame of the device provided for performing holes in base M16-7N.

The part of building works reduce, because the bearings eventually break their seats. For this body made of antifriction material GI20 GOST1412-79.

So choose cast iron thanks to its chemical and mechanical properties. The part has 2 holes ∅170H7 that are accurate and coaxial and ∅170H7 hole that is strictly perpendicular to them. The accuracy of alignment holes after take out the diamond to diamond boring - boring. Also, this method achieved roughness landing holes R_0 = 2,5 mm. After machining, parts are checked for alignment. Allowable alignment less than 0.03 mm; not permissible perpendicular not more than 0.05 mm; the intersection of the axes no more than 0.03 mm.

Table 1.1 - Chemical properties of gray iron GI20 [1]

C	Si	Mn	S	P	Ni	Cr
			Not more than			
3,3-4%	0,21-0,52%	0,31-0,36%	0,046%	0,04%	0,25%	0,2%

Table 1.2 - Physical and mechanical properties GI20 [1]

Physical		Mechanical		
The density ρ, 10 kg / m	The coefficient of linear expansion of 10 K	$\delta_{вр}$, 10^6 Pa	$\delta_{вз}$, 10^6 Pa	HB
7,3-7,4	10-12	200	400	170-241

Table 1.3 - Technological quality GI20

$K_{ц.р.}$	$K_{т.ц}$	Machining cutting	
		HB	$K_{э}$
1,3	0,9	170 - 241	0,9-1,2

Compliance geometric shape and size check caliber - plug and match pre-determined roughness on samples of surface roughness and selectively on profilers - profilografs. Remnants specification control universal instrument dimensional and visual inspection of surfaces. In technical terms the drawing body should get rid of the old symbols' roughness, precision surfaces; clarify and put down all the necessary dimensions for manufacturing and controlling the parts. Then all these factors are specified by standards. So drawing parts designation replaced the old class roughness.

Casting tilts the refinement to take the values $1\text{-}3^0$ as shown in the drawing blanks factory. Also specified accuracy tolerance of two coaxial holes and replaced the old to the new designation: instead $\varnothing 120A^{(+0.080)}$ not true, values entered $\varnothing 120H7^{(+0.022)}$. The mass of the parts in terms specified in the drawing 1.2 kg, 12 kg substitute. Also, put into a drawing some species (for example, type F and type T) for a visual display surface of the shell. All other dimensions, tolerances and designations accept without corrections and clarifications. It's drawn together as drawing the parts on A1.

1.2. Analysis of the technology of the part (qualitative and quantitative characteristics).

This piece body is made of casting rods with sand. For housing as a billet casting can be used in the form of sand with machine forming, but this method requires high energy costs and expensive equipment, as well as sand casting, must consider greater allowance for processing than for chill casting. Chill equipment is also quite expensive, but compared to the previous method of obtaining it is cheaper blank and blank metal is obtained with less resistance.

In case there are openings: hole 2 and hole $\varnothing 120^{+0.022}$ and $\varnothing 170^{+0.08}$ - seats for bearings. These holes should be processed alignment to within 0.03 mm perpendicular to within 0.05 mm. The only way to achieve these parameters is the ultimate diamond processing (boring) holes on the diamond - boring.

Is non-technological hole for the breather, which is located at 45^{0} to the central axis, making it difficult to access the cutting tools to handle this hole. However, this disadvantage is not essential because the location of the hole for the breather requires performance as a whole unit, so leave the enclosure without changes. In general, we can now consider building technology, because all surfaces that are treated with the correct geometric shape, simple; and have free access to handle a particular instrument and other openings, surfaces remain unchanged.

To determine the quantitative characteristics of adaptability make up the hull design analysis data table surfaces. Weight of part m_{∂} = 12 kg. Weight of the workpiece m_{01} = 14,3 kg; m_{02} = 15,5kg.

Table 1.4 - Data analysis design surface casing

Surfaces	Number	*K* - number of standartized elements	Quantity	Roughness
Bottom bases	1	-	14	12,50
Hole M16-7N	4	1	7	3,20
ends	4	2	11	3,20
Key hole	3	1	11	12,50
Holes M10	12	2	7	12,50
The surface 163,5h10	1	1	14	12,50
	Q_e=25,1	$Q_{y.e}$=7		

The cost of basic analog $C_{бт}$ = 5,45 UAH. The level of adaptability. The part in forging technology, because of its cost to the equalization of basic analog decreased by 15%. Factor unification of constructive elements: Non-technological.

The utilization of material:

$$Kв * m1 = m\, g/m_{01} = 12/14,3 = 0,84;$$

$$Kв * m2 = m\, g/m_{02} = 12|/5,5 = 0;75.$$

Precision machining ratio:

$$K_{тч} = 1 - 1 * (1/A_{ср}),$$

where $A_{ср}$ - average (coefficient) of accuracy;

$$A_{ср} = (7,19+11,4+14,2)/25 = 8,21;$$

$$K_{тч} = 1 - 1,1 * (1/8,21) = 0,88 › 0,8 \text{ – technology.}$$

Coefficient of surface roughness:

$$K_{ш} = 1/B_{ср},$$

where $B_{ср}$ - average surfaces' roughness;

$$B_{ср} = (3.2 * 12.5 * 8 + 17) / 25 = 9,524;$$

$$K_{ш} = 1 / 9,524 = 0,105 < 0,32 \text{ – technological.}$$

So, the whole piece is enough technology and permits the use of highly efficient processing modes.

1.3. Analysis of existing (base) of the process of manufacturing.

When processes are studied, existing problems deeply analysed, because without it, it's impossible to assess the process and to offer to its improvement and modernization. The following list of questions:

1) Rationality method of part's obtaining. For existing factory process billet produced by casting in sand - clay form, and as mentioned above, this method is impractical, costly and resource-. It is proposed to produce billet chill casting rods with sand, which is viable and feasible from an economic point of view. We need to make allowances for the National chill casting.

2) Databases right choice. Black, clean and intermediate base in this technological process selected correctly. But we need to get rid of a large number of instalations at one and the same operation as shown in operation 050 vertical - drilling holes where processed ∅8,4 ends.

Also in operation 065 vertical-boring handled a large number of surfaces with a large number reinstalling parts per shift, and with many changes of tools. This is true of operations: radial 070 - 075 drilling and threading.

In general, given the manufacturing process contains advanced cutting conditions, tool and others. However, to improve basic TP and its reduction in this thesis project offered to replace a certain number of technological operations that bring them into one aggregate transaction will significantly reduce the duration and complexity and increase the level of automation of the process.

Analysis of the existing manufacturing process will be conducted in terms of the quality of a given product. In other words, the analysis of the process should clarify whether it is true he prepared to meet the requirements or drawing and follow all the requirements of the process in the shop.

1.4. Recent advances in technology, machinery and equipment in the manufacture of such products.

The treatment of external surfaces holds strict buildings, milling, grinding, broaching. Productivity is low. Raise it possible by simultaneous treatment group components by placing them in one or two rows on the machine. Milling planes basic parts used mainly in the medium-and serial production. Setting it possible groups and also several mills by computing can significantly reduce the time to process them. Processing housings group performed during the installation of one or two rows, milled groups by computing in these different surfaces.

In high-volume mass production and received continuous use of milling cutters on planes face and rotary drum-milling machines. In mass production plane buildings often extended to handle machines.

Cases with outer surface rotations, cut into rotary-lathes. Finish bodies planes in the middle and high-volume production is often performed on surface-grinding machines grinding wheel periphery or the end face AC team - segmented circle. Major openings in buildings are often treated to boring, boring - turning and modular machines and sometimes turning on. In serial and mass production bore holes through special devices in which the tool has a one-way direction of the middle or the back or the front and back simultaneously. With front and rear areas handled short holes. Long holes with the front or rear direction.

Many models of modern horizontal-boring machine equipped with an optical system scales, providing precision timer to 0.01 mm. In jig - boring high precision coordinate is carried out with an accuracy of 1 micron.

An important direction of development of CNC machine construction is to create machines with automatic tool change. High-speed machines, devices for changing tools allow to use in the processing of complex body parts large sets of different tools (100 pieces), reduce time on their reinstallation, setting the size and enables workers to serve several machines. Reducing the time to change machining parts for some machines provided by the presence of two or more positional becomes. Application of machine tools with program management, combined with modern computer-based group led to the creation of specialized production areas and automated self control plants.

1.5. Conclusions and problem definition to project.

This thesis project in manufacturing engineering, obviously cannot fully meet the design, which consists in the production environment. In addition, the project performed a number of works, mainly the estimated character is not always carried out in the factory. However, this project should focus on possible methods of design and execution, taken in manufacturing, especially in the technical documentation.

Thus, the main objective of this diploma project is the development of new technological processes of parts by removing basic technical process of some operations and the introduction of a single aggregate transaction. The next stage of the project is to design specific machine and controlling devices.

2. TECHNOLOGICAL CHAPTER

In the development process of machining before technologist is always a problem: choose from several options for handling one that would ensure the most cost-effective solution. Modern methods of machining have a large variety of machine tools and new methods of processing metals - all to make different versions of technologies that provide manufacturing products that fully meet all the requirements of the drawing.

2.1. Determination of organizational type of production.

Production type best describes the rate of consolidation of operations, which determines the ratio of the number of operations jobs:

$$K_{зо} = \frac{O}{P}.$$

Consequently, the production volume is: N = 50 000 units.

Writes the basic time on operations (min.):

$T_{005} = 4,9$	$T_{035} = 4,6$	$T_{065} = 4,34$
$T_{010} = 0,33$	$T_{040} = 4,8$	$T_{070} = 0,28$
$T_{015} = 0,48$	$T_{045} = 0,2$	$T_{075} = 1,56$
$T_{020} = 6,54$	$T_{050} = 0,74$	
$T_{025} = 9,6$	$T_{055} = 0,2$	
$T_{030} = 8,96$	$T_{060} = 0,22$	

Artificially-calculation time (min):

$T_{шк1} = 3,14$	$T_{шк6} = 2,86$	$T_{шк11} = 0,69$
$T_{шк2} = 0,95$	$T_{шк7} = 5,08$	$T_{шк12} = 0,67$
$T_{шк3} = 1.14$	$T_{шк8} = 5.92$	$T_{шк13} = 9,8$
$T_{шк4} = 4,02$	$T_{шк9} = 0,79$	$T_{шк14} = 1,36$
$T_{шк5} = 3,04$	$T_{шк10} = 1,59$	$T_{шк15} = 3,2$

$$T_{шт} = 3{,}14 + 0{,}95 + 1{,}14 + 4{,}02 + 3{,}04 + 2{,}86 + 5{,}08 + 5{,}92 + 0{,}79 + 1{,}59 + 0{,}69 + \\ +0{,}67 + 9{,}8 + 1{,}36 + 3{,}2 = 44{,}26 \text{ min.}$$

$$T_{штср} = \frac{44{,}26}{15} = 2{,}95 \text{ min.}$$

The number of operations assigned to one workplace:

$$O_{рм\,i} = \frac{60 F_м K_в \eta_{нi}}{T_{шк} N_м},$$

where η - regulation load factor all operations jobs, η = 0,70;

F_M - month fund operating time of equipment; 334,51; $F_M = h$;

N_M - the number of parts in the party;

$T_{шк}$ - piece - calculation of an operation.

$$O_{рм1} = \frac{60 * 334{,}5 * 1{,}3 * 0{,}7}{3{,}14 * 41663{,}14 * 4166} = \frac{18263{,}7}{3{,}14 * 4166} = 1{,}3 \approx 1;$$

$$O_{рм2} = \frac{18263{,}7}{0{,}95 * 4166} = 4{,}6 \approx 5;$$

$$O_{рм3} = \frac{18263{,}7}{1{,}14 * 4166} = 3{,}8 \approx 4;$$

$$O_{рм4} = \frac{18263{,}7}{4{,}02 * 4166} = 1{,}1 \approx 1;$$

$$O_{рм5} = \frac{18263{,}7}{3{,}04 * 4166} = 1{,}3 \approx 1;$$

$$O_{рм6} = \frac{18263{,}7}{2{,}86 * 4166} = 1{,}4 \approx 1;$$

$$O_{рм7} = \frac{18263{,}7}{5{,}08 * 4166} = 0{,}8 \approx 1;$$

$$O_{рм8} = \frac{18263{,}7}{5{,}92 * 4166} = 0{,}7 \approx 1;$$

$$O_{рм9} = \frac{18263{,}7}{0{,}79 * 4166} = 5{,}5 \approx 5;$$

$$O_{рм10} = \frac{18263{,}7}{1{,}59 * 4166} = 2{,}7 \approx 3;$$

$$O_{рм11} = \frac{18263,7}{0,69*4166} = 6,3 \approx 6;$$

$$O_{рм12} = \frac{18263,7}{0,67*4166} = 6;$$

$$O_{рм13} = \frac{18263,7}{9,80*4166} = 0,4 \approx 1;$$

$$O_{рм14} = \frac{18263,7}{1,36*4166} = 3,2 \approx 3;$$

$$O_{рм15} = \frac{18263,7}{3,2*4166} = 1,4 \approx 1.$$

Since,

$$K_{зо} = \frac{1*1+1*5+1*4+1+1+3+3+1+10+3+6+72+2+3+1}{15} = 7,7$$

- high-volume production.

Corrects the batch size.

Determine the number of changes to the processing of the whole party parts:

$$C = \frac{T_{шкср} * N_c}{480*0,8} = \frac{2,95*2371}{480*0,8} = \frac{6994,45}{384} = 1,8;$$

$$N_c = \frac{N*12}{253} = \frac{50000*12}{253} = 2371.$$

$C_{пр}$ = 2 changes - reduced number of shifts.

Determine the beat output components with high-volume production:

$$t_в = \frac{F_д * 60}{N}\text{, min/pieces;}$$

where F_d - actual annual fund operating time of equipment;

N - annual production volume of details, pcs.

$$t_в = \frac{4140*60}{50000} = 5 \text{ min/pieces.}$$

2.2. Selecting of a method for producing blanks.

Choosing the workpiece is challenging due to many factors, the impact of which on different occasions mixed. Therefore, the selection method of manufacturing blanks impact comprehensively review possible options with a detailed technical and economic justification favourites. Of particular importance is the selection method of manufacturing a billet for flexible and automated production because they require higher precision shapes, sizes, and smaller changes properties of blanks like.

Basically method of producing billets-picked in the order analyse factors determining affecting the method of manufacturing blanks, define the material and constructive form of billets, analyse opportunities blanks for standard parts, assortments, materials that are produced (intermittent, long products, casting , forgings, etc.); choose a method of producing billets and basic equipment; carry out technical - economic justification and calculations.

Of course choose not one but several methods, alternatives which determine the technical - economic indicators and their analysis based on selected most efficient. For all types of production advisable to make casting; open design for mass and serial production - casting, and for small-scale and individual production - welding. The basic version of billet production is sand casting rods with sand with machine molding, this method is long and requires little energy use and cost of equipment. Another feature of casting sand form is quite large machining allowances, affecting a larger use of the material.

For this profitable parts in mass production to produce billet casting in metal molds - from sand casting rods. This method of producing billets in this body is profitable and cheaper, and material - GI20 GOST1412-85 is casting well. Machining allowances are determined relative to the internal machining of holes and the ends of the workpiece and are much lower than for sand casting. The plane connectors are shown in the drawing.

Thus, we determine the economic impact of choice piece of 2 ways.

Price billet obtained by casting:

$$S_{заг} = \left(\frac{C_i}{1000} * Q * K_T * K_c * K_в * K_м * K_п\right) - (Q - q)\frac{S_{відх}}{1000}, \text{ UAH;}$$

where C_i - base price blanks, UAH; C_i = 290 UAH;

Q - weight of the workpiece, kg; Q_1 = 14,30 kg; Q_2 = 15,50 kg;

q - finished part weight kg; *q* = 12,00 kg;

$S_{відх}$- price of 1 ton of waste UAH; $S_{відх}$ = 14,40 UAH;

$K_т$, $K_с$, $K_в$, $K_м$, $K_п$ - factor depending on the accuracy class, a group of complexity, weight, grade material and the production volume workpieces;

$K_т$=1,06; $K_м$=1; $K_с$=0,7; $K_в$=0,84; $K_п$=0,52.

Consequently, the price of billet obtained sand casting:

$$S_{заг2} = (\frac{290}{1000} * 14{,}3 * 1{,}06 * 1 * 0{,}7 * 0{,}84 * 0{,}52) - (14{,}3 - 12) * \frac{14{,}4}{1000} = 1{,}3 \text{UAH}.$$

The economic effect

$$Є_з=(S_{заг2}- S_{заг1})N, \text{ UAH};$$

$$Є_з = (1{,}725 - 1{,}311) \cdot 50000 = 20700 \text{ UAH}.$$

2.3. Selection of technological bases.

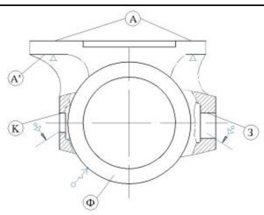
The base is called the original surface that determines the position of the workpiece in the processing of machined parts or ready assembled car or node.

When processing workpieces obtained by casting and stamping, rough surface as a base can be used in the first operation.

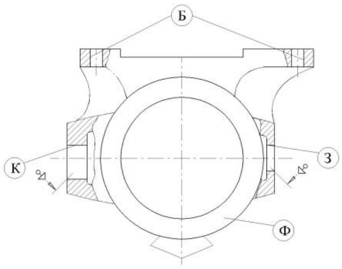
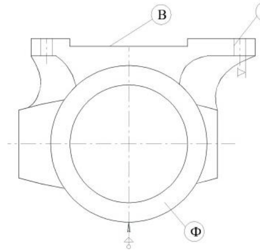
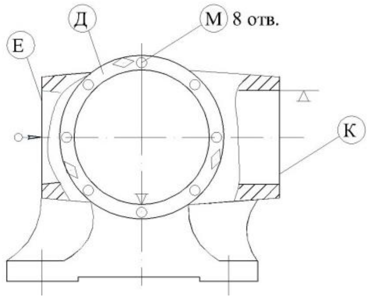
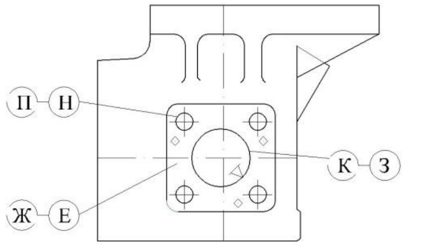
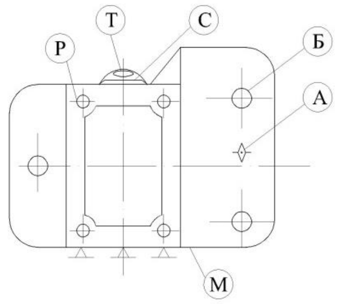
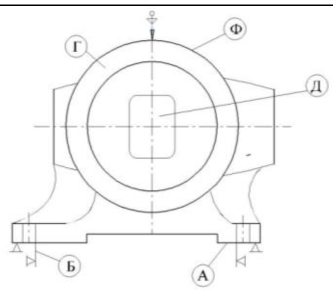
In the parts that cannot be fully processed, the technological base for the first operation is recommended to take surface, which generally are not processed, it will provide the least bias with raw machined surfaces.

For details of the body 714252.004, the choices of technological bases are present in the table 2.1.

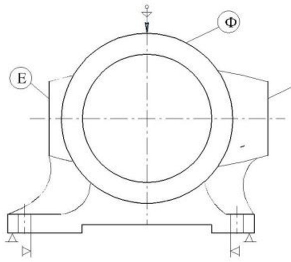
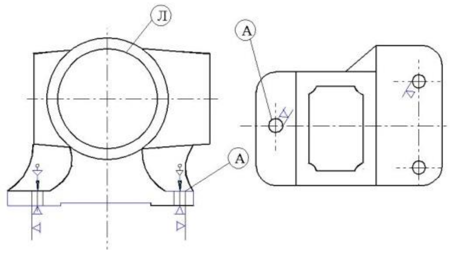
Table 2.1 – Selection of technological bases

Number of oper.	Basing surface	Machining surface	Sketch base
1	2	3	4
005	Ф А’ З К	А	

Continue table 2.1

1	2	3	4
010-015	Ф З К	Б	
020	Ф Б	В	
045-055	К Д Е	М	
050-055	К Ж Е З	Н П	
5060	М А	Б Р С Т	
025	А Б Ф	Г Д	

Continue table 2.1

030	Б Ф	Е Ж	
035-040	Б А	З К Л	

2.4. Structural analysis of two options machining process route and the choice of optimal.

Since the deployment in the processing performed on rough surfaces, there is no content base route processing so in order to obtain the first clear base surface operations. When choosing a treatment route guided by the following considerations:

1) because of the risk of redistribution of internal stress and the resulting deformation of the details (particularly significant for casting) process starts with less precision surfaces when removing them from the largest allowances;

2) to prevent cavities and cracks primarily perform removal allowance of the largest surfaces where such defects are unacceptable;

3) to reduce the length by moving parts of equipment placed on the direction of flow.

Methods of treatment of surface details and methods of processing when performing intermediate operations assign based on the requirements that apply to accuracy and quality of finished parts, given the nature of the workpiece and the processing properties of the material. For pre-selection method of the individual surface of the parts using data contents route compared. To compile this table comparison processing routes.

Table 2.2 - Comparative analysis processing routes

Options machining		
Base	Design I	Design II
1) Milling surface 1 one body	1) Milling surface 1 in three bodies	1) Milling surface 1 in three bodies s
2) Drilling of three holes 2 turns	2) Drilling of three holes 2 simultaneously	2) Drilling three holes 2 simultaneously
3) Milling groove 3 in one body	3) Milling of groove 3 in three buildings	3) Milling of groove 3 in three buildings
4) Milling in turn two ends 4 and 5	4) Milling single out on time two ends 4 and 5	4) Milling both ends 4 and 5, 6
5) Milling in turn two ends 6 and 7	5) Simultaneously shaping the two ends 6 and 7	5) Milling of holes 8, 9 and 10 at the same time
6) Boring two holes 8 and 9, and 10	6) Boring two holes 8 and 9, and 10	6) Diamond bore holes 8 and 9, 10 without re mouth
7) Diamond boring holes 8 and 9, then 10	7) Diamond boring holes 8 and 9, then 10	7) Drilling holes while eight 11
8) Drilling holes eight turns 11	8) Drilling eight holes 11 simultaneously	8) Drilling 4 holes 12 re-installation 4 holes 13
9) Chamfering	9) Chamfering	

Therefore, the analysis compared three options trails treatment shows that in paragraph 1 to the base variant surface 1 milled in only one body, and in two comparative project also is done simultaneously in three buildings, which is advantageous in terms of saving time on installation and removal of parts is reduced preparatory - the final time, the same goes for in paragraph 3. in paragraph 2 holes 2 also replaced by three simultaneous drilling spindle drilling point 4.5 to handle the basic version milling side of the body is by - the next being substituted in the reported option for simultaneous milling and ends 2 4.5, and then ends 6 and 7. The second option in the project end milling 4,5,6 held simultaneously, butt 7 is left without treatment.

The rest of the points speak for themselves that is radically changing treatment option for second project using modular machine for 10 points.

2.5. Determination of allowances on operational dimensions, workpiece design.

Analytical calculation of conduct for opening ∅120 $^{+0.022}$ and determine allowances on operational dimensions. Preparation is the casting and precision class, weighing 1,43 kg. The technological route processing ∅120 $^{+0.022}$ hole consists of rough, finish and diamond boring. Preparation for this operation is based on three holes na3 fingers on a plane basis. All calculations tabulates 2.5.

The total value of R_z and T characterizing the surface of cast billets choose from [1]; R_z = 200, T = 300.

After the first technology transfer value of T for details of cast iron is eliminated because all other passages we find only the value R_z, respectively 50,20 and 8 microns [1].

Table 2.3 - Calculation of allowances and size limits on technology

The technological transition surface treatment ∅120 $^{+0.022}$	Elements allowance microns				Estimated allowance 2Zmin, mkm	Estimated size d_p, mm	Tolerance δ, mm	Maximum size, mm		Limit values allowance, mkm	
	Rz	T	ρ	ξ				d_{min}	d_{max}	$2Z^{np}_{min}$	$2Z^{np}_{max}$
Workpiece	200	300	343	-	-	116,08	400	116,58	116,98		
Rough cutting	50	-	17	821	2*1389	119,758	220	119,538	119,758	2778	2958
Finishing cutting	20	-	-	41	2*94	119,846	100	119,846	119,946	188	308
Diamond cutting	8	-	-	18	2*38	120,0	22	120,0	120,022	76	154
Total										3042	3420

The total value of spatial variations logging of time is given by:

$$\rho_з = \sqrt{\rho^2_{кор} + \rho^2_{см}}\,.$$

The value of warping of the hole should be considered as the diametric and axial sections, so

$$\rho_{кор} = \sqrt{(\Delta_к d)^2 + (\Delta_k l)^2};$$

its value of the specific warping is found in [1], Δ_k = 0,70 mm (*d* and *l* - machining diameter and length of the hole);

$$\rho_{кор} = \sqrt{(0,7*120)^2 + (0,7*251)^2} = 194 \text{ mkm}.$$

The overall bias in the casting hole relative to the outer surface is a geometric sum of two mutually perpendicular planes:

$$\rho_{см} = \sqrt{(\frac{\delta_б}{2})^2 + (\frac{\delta_г}{2})^2} = \sqrt{(\frac{400}{2})^2 + (\frac{400}{2})^2} = 284 \text{ mkm},$$

$\delta_б = \delta_г$=0,40 mm [1].

Thus, the total value of spatial deflection piece is:

$$\rho_3 = \sqrt{284^2 + 194^2} = 343 \text{ mkm}.$$

The value remaining after spatial deviation rough boring:

$$\rho_1 = 0,05\rho з = 0,05*343 = 17 \text{ mkm}.$$

Error when installing rough boring:

$$\xi_1 = \sqrt{\xi^2 \delta + \xi^2{}_з},$$

$S_{max}=\delta_A + \delta_B + S_{min}$- minimal clearance between the hole and the pins;

δ_A - admission to the opening; δ_A = 400,0 mkm = 0,4 mm;

δ_B - admission to the diameter of the probe; δ_B = 200,0 mkm = 0,20 mm;

S_{min} - minimal clearance between the pin and hole diameter;

S_{min} = 0,10 mm = 100,0 mkm.

Then the maximum rotation angle of the workpiece on the pins is:

$$\text{tg}\alpha = 0,00661.$$

Accuracy deployment:

$$\xi_б = l * \text{tg}\alpha = 251,0*0,00660 = 1,60 \text{ mm} = 1600 \text{ mkm}.$$

The error fixing piece ξ = 100 microns [1]. Then the error of boring in the draft:

$$\xi_1 = \sqrt{1600^2 + 100^2} = 821 \text{ mkm.}$$

The residual error of finish boring:

ξ_1 = 0,05 m; while the diamond boring microns.

Calculates the minimum values interoperable allowances by the formula:

$$2Z_{\min} = 2(R_{zi-1} + T_{i-1} + \sqrt{\rho_{i-1}^2 + \xi_i^2}.$$

Rough boring $2Z_{\min 1} = 2(200 + 300 + \sqrt{343^2 + 821^2}) = 2*1389$ mkm.

Finishing boring $2Z_{\min} = 2(50 + \sqrt{17^2 + 41^2}) = 2*94$ mkm.

Diamond boring $2Z_{\min} = 2(40 + \sqrt{18^2}) = 2*38$ mkm.

Calculate the estimated size:

d_{p1}=120,0221 – drafting;

d_{p2}=120,0221-0,0761=119,9460 mm;

d_{p3}=119,9460-0,1880=119,7580 mm;

$d_{pз}$=119,7580-2,7880=116,980 mm.

Tolerance for diamond boring is 22,0 microns; for fair δ=100,0; to draft δ=220,0 for casting on GOST 1855 δ=400,0 mkm.

The lowest limit:

$$d_{\min 1} = 120,022 - 0,022 = 120 \text{ mm;}$$

$$d_{\min 2} = 120,946 - 0,1 = 119,846 \text{ mm;}$$

$$d_{\min 3} = 119,758 - 0,22 = 119,538 \text{ mm;}$$

$$d_{\min з} = 116,98 - 0,4 = 116,58 \text{ mm.}$$

Minimum and maximum limits allowances:

Diamond boring:

$$2Z_{\min 3}^{np} = 120,022 - 119,946 = 76 mkm = 0,076 \text{ mm;}$$

$$2Z_{max 3}^{np} = 120 - 119,846 = 154 mkm = 0,154 \text{ mm.}$$

Finishing boring:

$$2Z_{\min 2}^{np} = 119,946 - 119,758 = 188 mkm = 0,188 \text{ mm;}$$

$$2Z_{max 2}^{np} = 119,846 - 119,538 = 308 mkm = 0,308 \text{ mm.}$$

Rough boring:

$$2Z^{np}_{\min 3}=119,758-116,98=2778mkm=2,778 \text{ mm};$$

$$2Z^{np}_{\min 3}=119,538-116,58=2958mkm=2,958 \text{ mm}.$$

General allowances

$$2Z_{0\min}=76+188+2778=3042mkm=3,042 \text{ mm};$$

$$2Z_{0\max}=154+308+2958=3420mkm=3,42 \text{ mm}.$$

Total nominal allowance

$$2Z_{ном}=3042+251-120\approx 3173 \text{ mkm}.$$

$$dз_{ном}=d_{дном}-Z_{оном}=120-3,173=116,9 \text{ mm}.$$

The remaining allowances on select tables and makes allowances summary in table 2.4.

Table 2.4 - Allowance body parts

Surfaces and methods of treatment	Shorst-bone, mkm	Precision machining	Allowance, mm	Operating size, mm	
				calculated	with a tolerance
1	2	3	4	5	6
Bottom bases 255x20 Half finishing milling Preparation - casting	 12,5 80	 h14 h16	$Z1$=0.98 1	 h=20 h=23	 $h=20^{+2.0}_{-1.0}$ $h=20^{+2.0}_{-1.0}$
Hole M16-7H threading Boring Drilling Preparation - casting	 3,2 1,6 12,5 80	 7H H9 H11 H16	 - - - -	 M16 ∅14 ∅13,5	 M16-7H $∅14^{+0.043}$ $∅13,5^{+0.4}$
Surface 163,5x10 Half finishing milling Preparation - casting	 12,5 80	 h14 h16	Z_1=0,981	 h_1=10;B_1=163 h_2=9,1; B_2=160,5	h_1=10±0,2 B_1=163,5±0,5 $h_2=9^{+2.0}_{-1.0}$ $B_2=160^{+2.0}_{-1.0}$
2 ends ∅225; L=195 Half finishing milling Preparation - casting	 3,2 80	 h11 h16	$2Z_1$=2*3,0	 $L_1=195$ $L_2=201$	 $L_1=195\pm1,0$ $L_2=201\pm1$

Continue table 2.4

1	2	3	4	5	6
2 side in L=251,5 Half finishing milling Preparation - casting	 3,2 80	 h11 h16	$2Z_1$=2*3,0	L_1= 251,5 L_2= 257	L_1=251,5±1,0 L_2=257±1,5
2 holes $\varnothing 120^{+0.022}$ Diamond boring Finishing boring rough boring Preparation - casting	 12.5 20 40 80	 H7 H11 H12 H16	 2*0,038 2*0,094 2*0,138 2*3,4	 ∅120 ∅119,8 ∅119,5 ∅116	 $\varnothing 120^{+0.022}$ $\varnothing 119{,}8^{+0.4}$ ∅119,5±0,5 ∅116±0,5
Holes∅170H7 Diamond boring Finishing rough boring Boring Preparation - casting	 12,5 20 40 80	 H7 H11 H12 H16	 2*0,5 2*1,5 2*3 2*5	 ∅170 ∅167 ∅165 ∅159	 $\varnothing 170^{+0.080}$ $\varnothing 167^{+0.22}$ ∅165±1,5 ∅159±0,5
2 holes∅8,4 (M10) Threading Drilling Preparation - casting	 12,5 20 -	 7H H11 H12	 - - -	 ∅10 ∅8,4 -	 ∅M10-7H $\varnothing 8{,}4^{+0.35}$ -
2 holes∅14,4(M16) Threading Drilling Preparation - casting	 12,5 20 -	 7H H11 H12	 - - -	 M16x1,5 ∅14,4 -	 M16x1,5-7H ∅14,4

Casting slopes 1; radius curves 2÷5 mm [1].

These data do drawing blanks.

2.6. Dimensional analysis of the machining process.

Design of the constructions of details that best meet the requirements of interchangeability is ensured using dependent allowances and landings of various compounds and precision the relative position of parts in the beloved vehicles, machinery or other product. Dimensional relationship set parts dimensional circuits (GOST 16.319-80) - set size, forming a closed loop and describing this structure. Dear dimensional chain consists of a single-level locking, and two or more components that influence the accuracy level locking.

So, in this thesis project solve the inverse problem of determining closing level on admission famous parts of the dimensional chain.

To make up this dimensional chain.

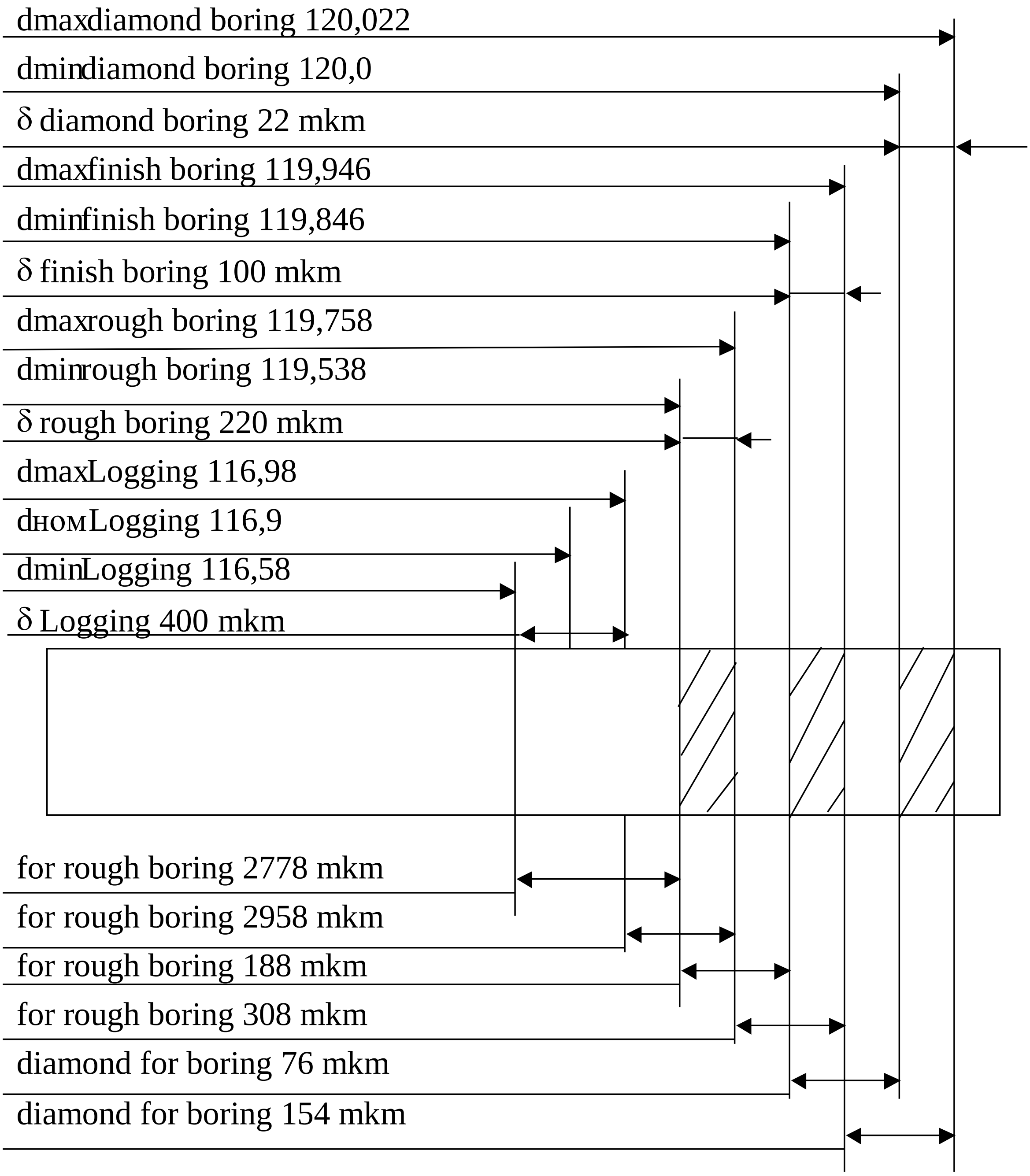


Figure 2.1 - Disposition cheme allowances and tolerances for processing $\varnothing 120^{+0.022}$

So we have a picture of $A_1 = 5^{+0.2}$ $мм$; $A_2 = 145^{+0,6}_{-0,5}$, $A_3 = 85^{+0,12}$ mm.

Need to know which accuracy is sustained longer than a given stage processing circuit. Building dimensional chain locking find increasing and decreasing level.

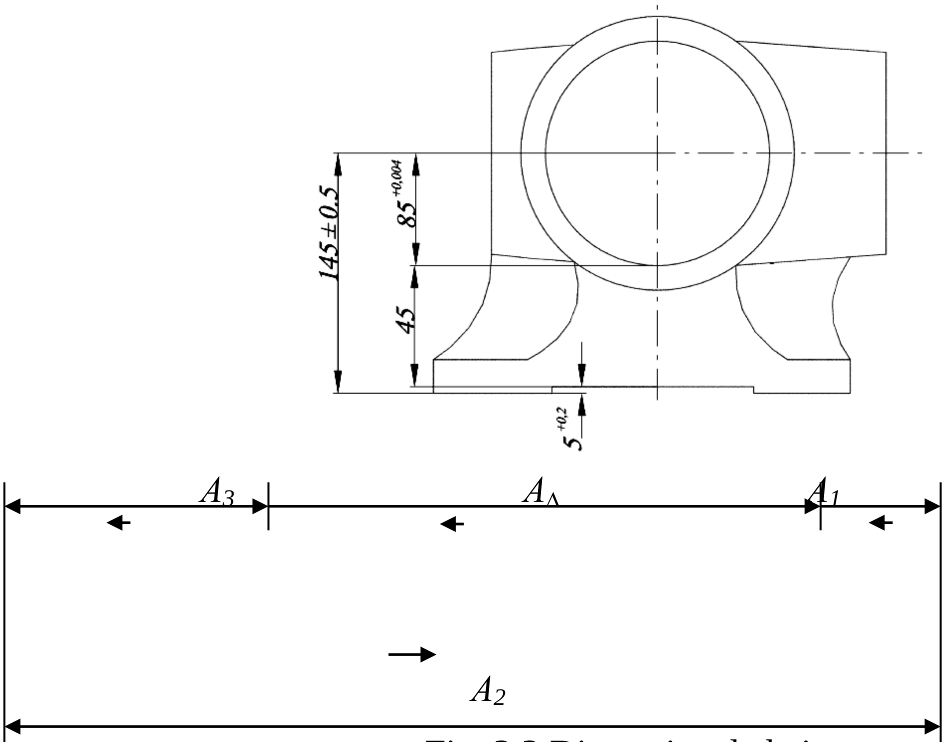


Fig. 2.2 Dimensional chain

The highest value closing level determined by the formula:

$$A_{\Delta} = -A_1 + A_2 - A_3 = -5 + 145 - 85 = 45 \text{ mm.}$$

Choosing a method of solving the problem of dimensional chain.

Solve the problem by maximum - minimum.

Determine the coordinates of the middle of the tolerance field locking links:

$$\Delta_{o\Delta} = (+0,02) + (-0,25) - (+0,06) = -0,33\text{mm.}$$

The value of the tolerance field level locking knows the equation:

$$0,04 + 0,5 + 0,12 = 0,66 \text{ mm.}$$

Maximum deviations knows locking link:

$$\Delta_{в\Delta} = \Delta_{o\Delta} + \frac{\delta_{\Delta}}{2} = -0,33 + \frac{0,66}{2} = 0;$$

$$\Delta_{н\Delta} = \Delta_{o\Delta} - \frac{\delta_{\Delta}}{2} = -0,33 - \frac{0,66}{2} = -0,66.$$

Ultimately, if we get $A_{Д}$ = 45,0.

2.7. Selection of machining tools.

This section selects cutting tools and measuring tools for each operation of the process of machining. If selected and dimensional cutting instrument can be considered clear cutting conditions. Choose the tools required for the following criteria:

- depending on the type of production;
- depending on the type of machining and precision machined surface;
- depending on the material being processed;
- depending on the size machining surfaces, and others.

The basis of selection up guides and guests. So are summarized in table tool is selected.

Table 2.5 - Cutting and measurable tool

Operation	Cutting tool	Measuring tool
1	2	3
005 Vertical - milling	End milling (∅320 mm) *Z*=20;BK8;GOST8529-69 *B*=75 mm; *d*=128,57 mm	Templates special
010 Vertical - drilling	Heads boring; drill (∅13,5) GOST 10903-77;P18	Template for location; template ∅13,5
020 Horizontal - milling	Special cylindrical cutter (∅164)	Templates special ∅ $164_{-0,5}$
015 Radial - drilling	Reamer (∅14) P18 GOST1678-62	Special pattern, the location, cork∅14H9
025 Vertical milling	End milling BK8 GOST8529-69; *D*=250mm; *B*=128,57mm; *Z*=14	Template placement ends
030 Horizontal - milling	-//-	-//-
035 Horizontal - boring	Borshtanha, special cutter BK8 (∅16)	Inside НИ100-160 GOST868-72 special corks ∅119 НЕ-ПР ∅169 НЕ-ПР

Continue table 2.5

1	2	3
040 Diamond - boring	Borshtanha VK10 special cutter left (∅12) VK10 special cutter (∅12)	Stopper∅120 H7: ПР GOST 14823-69 НЕ GOST 14823-69 Stopper∅170H7: ПР GOST 14822-69 НЕ GOST 14822-69
045 Vertical -milling	Heads boring Drill P6M5 (∅8,5) GOST 10903-77	Stopper(∅8,5) special template placement
050 Vertical - drilling	Heads boring Drill P6M5 (∅8,5) GOST 10903-77	
055 Radial - drilling	Tap P6M5 (M10) GOST 3266-81 Bushing GOST15936-70	Stopper (M10-7H) GOST 17758-72
060 Aggregate	Drill P6M5 (∅6,8) GOST 10903-77 Drill P18 (∅14,5) GOST 10903-77 Drill conical R6M56 Special tap Special tapered R6M5 (∅19,772) Tap (M16x1,5) GOST 3266-81 Tap (M16) GOST3266-81 Tap (M8) GOST 3266-81	Special stopper(∅6,8) Templates special (∅14,5) Special stopper pattern placement Special conical pattern Special stopper (M19,772) stopper (M16) GOST 17768-72 stopper(M16) GOST 17758-72 stopper (M8) GOST 17758-72

2.8. Calculation of cutting operations. Choice of equipment.

Processing Æ120H7 2 holes (diamond finish).

1. Choose a cutting tool - cutter TZOK4 $\varphi = 90$; $\varphi_1 = 50$; holder - steel 45 [3].

2. Cutting depth $t = \frac{D-d}{2} = \frac{120-119}{2} = 0{,}5\,\text{mm}$.

Assign 3 to supply machine 0,111mm /rev [3],

$S = 0{,}1 \div 0{,}11$mm/rev [3], $K_s = 0{,}8$ - clarifying factor.

Adjusts supply to the machine $S_1 = 0{,}084$ mm/rev.

4. The period of stability cutter *t* = 60 min.

5. Determine the cutting speed:

$$\upsilon_i = \frac{C_\upsilon}{T^m t^{x_v} S^{y_v}} K_v,$$

Enters coefficients and exponents from [3]:

$$C_v = 420;\ x_v = 0{,}15;\ y_v = 0{,}20;\ m = 0{,}20.$$

Clarifying factors $K_{\text{в}v} = 0{,}9$.

$$K_{\text{м}v} \frac{75}{\delta \text{в}} = \frac{75}{44} = 1{,}7 \text{ [3]},$$

$$K_{uv} = 1{,}49 \text{ [3]};\ K_{\varphi v} = 0{,}7 \text{ [3]};$$

$$\delta_i = \frac{420}{60^{0.2} * 0{,}5^{0.15} * 0{,}084^{0.2}} * 1{,}7 * 1{,}4 * 0{,}7 = 555 \text{ mm/min.}$$

6. Frequency spindle

$$n = \frac{1000\delta i}{\pi D} = \frac{1000 * 555}{3{,}14 * 120} = 2077{,}3 \text{ rev/min.}$$

Adjustable speed n_q=2000 rev/min.

7. Cutting speed

$$\upsilon_q = \frac{\pi D n_q}{1000} = \frac{3{,}14 * 120{,}022 * 2000}{1000} = 534 \text{ m/min.}$$

8. Power cut

$$N_p = \frac{P_z \upsilon_q}{60 * 102}.$$

Power cut $P_z = C_{pz} t^{x_{pz}} S^{y_{pz}} \upsilon^{n_{pz}} K_{pz}$.

Choose the coefficients and exponents [3]:

C_p=300; x_p=1; y_p= 0,75; n_p= 0,15.

Clarifying rates

$$K_{мр} = (\frac{\delta_в}{75})^{np}; n_p = 0,75 \text{ [3]}; \; K_{мр} = (\frac{44}{75})^{0,75} = 0,67;$$

$$K_{\varphi p} = 0,891 \text{ [3]};$$

$$P_z = 300 * 0,5^1 * 0,084^{0.75} * 5,34^{-0.15} * 0,67 * 0,89 = 59 \text{ N};$$

$$N_{різ} = \frac{5,9 * 5,34}{60 * 102} = 0,515 kW.$$

9. Regular time

$$T_0 = \frac{L_i}{nS},$$

$$L = l + y + \Delta;$$

$$y = ctg 90^0 = 0,5 * 0,58 = 0,31; \; \Delta = 2 \text{ mm};$$

$$L_A = 15 + 0,31 + 2 = 17,31 \text{mm}; \; L_Б = 38 + 0,31 + 2 = 40,31 \text{ mm};$$

$$T_{OA} = \frac{17.31}{2000 * 0,084} = 0,103 \text{min}; \; T_{OБ} = \frac{40,31}{2000 * 0,084} = 0,24 \text{ mm};$$

$$T_{0\Sigma} = 0,103 + 0,24 = 0,343 \text{mm}.$$

Milling of the bottom plane basics $h = 20^{+2.0}_{-1.0}$ [3].

1. The cutting tool–cutter∅200 T15KB of false teeth, face [3], geometry: $\acute{\alpha}$=20^0; γ=20^0;φ=60^0;φ_0= 45^0.

2. Cutting depth t=h=1 mm.

3. Submission of a tooth cutters:

$S_z = 0,09 \div 0,18$ mm/tooth [3].

Accepted $S_z = 0,18$.

4. The period of stability cutters T= 240 min [3].

Permissible wear of tooth $h_з = 0,4$ mm (table 10, p. 154).

5. Cutting speed

$$\upsilon_i \frac{CvD^{qv}}{T^m t^{xv} S_z^{yv} Z^{pv}} K_v.$$

Choose the coefficients and exponents [3]:

$$C_v = 41: \; q_v = 0,251; \; x_v = 0,10; y_v = 0,4; \; u_v = 0,15; p_v = 0,10; \; m = 0,20.$$

Clarifying rates $K_{nv} = \frac{75}{\delta в} = \frac{75}{44} = 1,7$ [3].

K_{nv}=0.8; K_{iv}=1;$K_{\varphi v}$= 1.

$$\upsilon_i = \frac{41*200^{0.25}}{240^{0.2}*1^{0.1}*0,18^{0.4}170^{0.15}*12^{0.1}}*1,7*0,8 = 47 \text{ m/min.}$$

6. Frequency spindle

$$n = \frac{1000\upsilon i}{\pi D} = \frac{1000*47}{3,14*200} 74,8 \text{ rev/min.}$$

Minute to adjust supply machine n_g=80,0 rev/min.

7. The actual cutting speed

$$\upsilon g = \frac{\pi D n_g}{1000} = \frac{3,14*200*80}{1000} = 50,24 \text{ m/min.}$$

8. Minute presentation $S_м = S_z * z * ng = 0,18*12*80 = 173$ mm/min.

Minute to adjust supply machine $S_м$=160 mm/min.

9. Valid values applying for a tooth

$$S_{zg} = \frac{Sм}{Z*ng} = \frac{160}{12*80} = 0,17 \text{ mm/t.}$$

10. Determine circular cutting force:

$$P_z = \frac{C_p t^{xp} * S_z^{yp} * B^{yp} * Z}{D^{yp} * n^{\omega p}} k_p.$$

Odds and exponent [3]:

C_p= 825;x_p=1,0; y_p=0,750; u_p= 1,10; ω_p =0,20; q_p=1,30.

Clarifying factors: $K_{мр} = (\frac{\delta_в}{75})^{np}; n_p = 0,75$ [3].

$$K_{мр} = (\frac{44}{75})^{0.75} = 0,67.$$

$$P_z = \frac{820*2^1*0,17^{0.75}*170^{1.1}*12}{200^{1.3}*80^{0.2}}*0,67 = 416 \text{ kgf.}$$

11. Determine cutting performance:

$$N_{різ} = \frac{P_z v_g}{60*102};$$

$$N_{різ} = \frac{416*50}{60*102} = 3,4\,\text{kW}.$$

12. Regular time

$$T_0 = \frac{L}{S_M} = \frac{305}{160} = 1,91 \text{ min};$$

$$L = \ell + y + \Delta = 255 + 47 + 3 = 305mm;$$

$$y = 0,5(D - \sqrt{D^2 - B^2}) = 0,5(200 - \sqrt{200^2 - 170^2}) = 47mm.$$

CourseΔ =3mm.

Then select the cutting conditions on tables and brings them to the table 2.6.

Table 2.6 - Selecting the cutting operations

Operation transition	t, mm	S, mm/rev, mm/min	N, rev/ min	v m/min	T_0, min
1	2	3	4	5	6
Vertical – drilling Drill 3 holes $\varnothing 13,5^{0.4}$ Show 3 holes $\varnothing 14H9^{(+0.043)}$	 - 0,25	 0,14 0,63	 355 200	 15,6 8,8	 0,33 0,48
Horizontal - milling milled groove 163,5x10±0,2	 1,5	 100	 80	 41,2	 6,54
Longitudinal – milling End mill at a rate of 1195±0,6 End milling in p 1120±0,5	 3 3	 125 100	 125 125	 0,8 78,5	 9,6 8,96
Boring hole∅119H9 Boring hole ∅119H9 Boring hole ∅170H9	1,5 1,5 1,5	0,135 0,135 0,188	215 215 154	81 78,3 82	0,34 0,52 0,3
Diamond - boring Boring hole∅170H7	 0,5	 0,1	 140	 75	 0,3

Continue table 2.6

1	2	3	4	5	6
Vertical - drilling Drill simultaneously 8 holes $\varnothing 8,4^{(+0.35)}$	 -	 0,2	 500	 13,3	 0,2
Vertical - drilling Drill 4 holes $\varnothing 8,4^{(+0.35)}$ (to pass)	 -	 0,3	 440	 11,7	 0,31
Vertical - drilling Drill 4 holes $\varnothing 8,4^{(+0.35)}$ i)	 -	 0,28	 250	 2,67	 0,2
Cutting the thread holes 8 M10-7N Cutting thread 8 holes M10-7	1,5 1,5	1,5 1,5	180 180	5,7 5,7	0,78 0,78
Aggregate Drilling holes 4 $\varnothing$6,7 Drilling holes $\varnothing$14,5 Drilling holes 2 $\varnothing$18,25 Cut the thread $\varnothing$19,772 (2 holes) Cutting thread M16 Threading the thread M16 (3 holes) Cutting thread M8 (4 holes)	 - - - 1,8 1,5 2,0 1,25	 0,09(45,5) 0,162(45,5) 0,216(45,5) 1,814 1,5 2,0 1,25	 505 280 210 130 160 160 256	 10,6 19,7 122,0 8,0 8,0 8,0 6,4	 0,49 0,66 0,62 0,104 0,143 0,133 0,09

Table 2.7 - Selecting machine tools

№ oper.	Power *N*, kW	Dimensions of the working surface, mm	Name and brands	Price, UAH
1	2	3	4	5
005	10,0	2245x3040	Vertical - milling 6550	32500
010	7,5	1290x875	Vertical - drilling 2H150	32500
015	4	2445x1000	Radial - drilling 2M55	45900
020	7,5	2100x2440	Horizontal - milling 6Р82Г	23300
025	7,0x2	5200x3520	Longitudinal milling ГФ1400	166500

Continue table 2.7

030	7,0x2	5200x3520	Longitudinal milling ГФ1400	166500
035	5	4300x2735	Horizontal - boring 2615	121300
040	2,2	1400x1900	Diamond - special boring machine	15500
045	7,5	1290x875	Vertical - drilling 2H150	32000
050	7,5	1290x875	Vertical - drilling 2H150	32000
055	4	2445x1000	Radial - drilling 2M55	45900
060	1,5x5	B1Г2H2Г	Aggregate special machine	≈44000

2.9. Specification of equipment.

At this point give specifications machine of participating in treatment for a particular transaction.

005. Operation characteristics of the vertical–milling machine mod. 6550.

1. Dimensions of the working surface became 500h1250 mm.

2. The maximum displacement was, mm:

Longitudinal 1000.

Cross 500.

Spindle530.

3. The distance from spindle end to surface became 100-630 mm.

4. Internal taper spindle 50.

5. Number of spindle speeds 18.

6. The frequency spindle, rev / min 31,5-1600.

7. Submission (without cascade control) mm / min .: became 10-2000.

Spindle 4-800.

Operation: 010,045,050.

Characteristics of vertical - drilling machines.

Mod. 2N150.

1. The maximum conditional ∅ drilling in steel, 50 mm.

2. Working surface became 500h560 mm.

3. The maximum distance from the end of the working spindle surface became 800 mm.

4. Departure spindle 355 mm.

5. Maximum spindle 320 course.

6. The greatest vertical movement, mm: 260 drilling head became 350.

7. The body opening spindle Morse 5.

8. Number of spindle speeds 12.

9. Speed spindle rev / min. 22-1100.

10. Submission spindle mm / rev 0,051-2,242.

11. Motor power main motion, kW 7,6.

12. Weight, kg 1875.

Operation 015.055. Characteristics radial-drilling machine 2M55.

1. Max drilling diameter in steel 50 mm.

2. Distance of spindle axis to column generatrix, mm 375-1650.

3. The most moving, mm:

vertical, column 755 on sleeve;

horizontal drilling heads on the sleeve 1220.

4. The greatest vertical movement of the spindle, mm.

5. Body Morse 5 spindle hole.

6. Number of spindle speeds 21.

7. The frequency spindle, rev / min 22-2100.

8. The number of innings spindle 12.

9. Feed spindle mm / rev 0,05-2,55.

10. Engine power kW 5,6.

020. Operation characteristic horizontal-milling machine 6R82H.

1. Internal spindle housing GOST 15945-82:

horizontal 50.

2. Number of spindle speeds 18.

3. The frequency spindle, rev / min 31,6-1610.

4. The number of workers was the 18 innings.

5. Feed became mm / min:

longitudinal 22-1255;

cross-20-1255;

vertical 8,4-416,7.

6. The speed of fast movement became mm / min:

longitudinal 3100;

cross 3100;

vertical 1100.

7. Motor power, kW 7,6.

8. Weight, kg 2950.

Operation 030.025. Milling machine mod. HF1400.

1. Working surface’s size became 1500h3000 mm.

2. The maximum weight of the processing of the workpiece, kg 1100.

3. The distance from the surface to become horizontal axis spindle 500.

4. The distance between the ends of horizontal spindles 345-745.

5. Max began moving lengthwise 1255 mm.

6. The frequency spindle, rev / min 15-1650.

7. Feed mm / min:

became 15-2500;

spindle 15-2500.

8. Engine power, kW 7,8h2.

9. Weight, kg 14500.

035. Operation characteristic horizontal - boring machine 2615.

1. Assembly machine.

2. Spindle diameter, 80 mm.

3. Dimensions (built) was the turning 900h1000.

4. Max displacement, mm:

vertical spindle 800;

longitudinal spindle 550;

radial caliper 120.

5. Number of speeds:

spindle 20;

chuck 15.

6. Frequency of rotation, rev / min:

spindle 22-1650;

chuck 8-200.

7. Feed, mm / min:

spindle 2,5-2500;

spindle 1,5-1285.

8. Engine power, kW 4,6; 6,8.

9. Weight, kg 8550.

040. Operation characteristics of diamond - boring machine mod. OS2706.

1. The diameter machining holes 8-250 mm.

2. Working surface’s size became 320h500.

3. Progress became 400.

4. The frequency spindle, rev/ min:

with sizes ranging heads:

II 3150/2550;

III 2000/1650;

IV 1255/1100;

5 Weight, kg 3600.

060. Operation projected special characteristic modular machine tools.

1. Productivity, pieces / h 30.

2. The number of spindles 18.

3. The drive clamp parts and supply hydraulic power unit.

4. Number of motors 12.

5. Electric motors’ total power of, 27,22 kW.

6. Overall dimensions machine:

length 4850;

width 5500;

height 3800.

7. Weight machines by taking into account ancillary equipment, kg 23650.

Technical regulation 2.10 of the process developed.

After determining the content of operations, indicative selection of equipment, tools and cutting conditions calculation of standard time is determined as follows:

1. For each move calculated basic (technological) time then.

2. The content of each switch installed the necessary range of methods of supporting and auxiliary time T_{don} is considering possible and useful combined and overlap.

3. For regulations depending on the operations and equipment installed in a service job, leisure and natural needs $T_{обс}$ i $T_{відп}$.

4. Determine the rate of artificial time $T_{шт}=T_o+T_{доп}+T_{відп}$.

5. Serial production is set preparatory composition - final work preparatory calculated - the final time artificially - a calculation $T_{шк}=T_{шт}=T_{пз}/n$.

Consequently, the guide hold select the time and record them in [9].

Table 2.8 - Calculation piece of time on operations process, min

Number and range operations	T_{oc}	$T_{доп}$			T_{on}	$T_{обсл}$		$T_{від}$	$T_{шт}$	$T_{п.з.шт}$	n, pieces	$T_{шк}$
		Instal. tools	Machine tool	Measuring		$T_{техн}$	$T_{орг}$					
1	2	3	4	5	6	7	8	9	10	11	12	13
005 Vertical - Milling	4,9	0,35	0,65	0,3	0,84	0,07	-	0,017	5,695	13,0	260	5,745

Continue table 2.8

1	2	3	4	5	6	7	8	9	10	11	12	13
010 Vertical - drilling	0,33	0,17	0,32	0,15	0,35	0,024	-	0,007	0,681	14,0	260	0,735
015 Radial - drilling	0,48	0,19	0,5	0,31	0,32	0,022	-	0,0064	1,0084	6,25	260	1,032
020 Horizontal - milling	6,54	0,3	0,58	0,28	0,65	0,067	-	0,013	7,2	9,0	260	7,235
025 Longitudinal - milling	8,96	0,30	0,55	0,25	0,81	0,062	-	0,0162	10,15	7,2	260	10,21
030 Longitudinal - milling	9,6	0,32	0,62	0,3	0,83	0,067	-	0,0166	10,31	16,15	260	10,37
035 Horizontal - Boring	1,16	1,2	1,5	0,3	2,34	0,26	-	0,047	2,967	20,15	260	3,042
040 Diamond - boring	0,64	1,4	1,81	0,41	1,3	0,143	-	0,026	2,62	21,02	260	2,7
045 Vertical - drilling	0,2	0,17	0,65	0,48	0,32	0,022	-	0,0064	0,88	6,12	260	0,91
050 Radial - drilling	0,62	0,17	0,79	0,62	0,32	0,022	-	0,064	1,5	6,24	260	1,524
055 Radial - drilling	1,23	0,19	0,79	0,6	0,35	0,024	-	0,007	20,51	6,25	260	2,07
060 Aggregate	2,23	0,17	0,37	0,2	2,63	0,184	-	0,053	2,837	23,05	260	2,93

2.10. Determining the amount of equipment. Calculation of download parameters of choosing equipment.

Proper selection of equipment determines the efficient use of time. When choosing tools developed for the technical process, this fact should be taken into account so as to exclude them simple, that is to select tools on productivity.

Each machine in the process is to be calculated load factor machine by main time.

Machine load factor is defined as the ratio of the estimated number of machines employed in technological process, the adopted (actual) number of machines m_n:

$$\eta_з = \frac{m_p}{m_n}.$$

In turn, the estimated number of machines is defined as the ratio of artificial time for one operation cycle $T_{шт}$ to release $t_в$:

$$m_p = \frac{T_{шт}}{t_в};$$

Tact release

$$t_в = \frac{F_g * 60}{N};$$

where F_g- actual annual fund of equipment,

N - annual volume program of parts, pcs;

$$t_B = \frac{4140 * 60}{50000} = 5.$$

Thus, the estimated amount of equipment and accepted will be:

Operation 005: $m_p = \frac{3,14}{5} = 0,6$ $m_n = 1$

Operation 010: $m_p = \frac{0,95}{5} = 0,2$ $m_n = 1$

Operation 015: $m_p = \frac{1,14}{5} = 0,2$ $m_n = 1$

Operation020: $m_p = \frac{4,02}{5} = 0,8$ $m_n = 1$

Operation025: $m_p = \frac{3,04}{5} = 0,6$ $m_n = 1$

Operation030: $m_p = \frac{2,86}{5} = 0,5$ $m_n = 1$

Operation035: $m_p = \frac{5,08}{5} = 1,02$ $m_n = 2$

Operation040: $m_p = \frac{5,92}{5} = 1,2$ $m_n = 2$

Operation045: $m_p = \frac{0,79}{5} = 0,2$ $m_n = 1$

Operation050: $m_p = \frac{0,69}{5} = 0,14$ $m_n = 1$

Operation055: $m_p = \frac{2,06}{5} = 0,4$ $m_n = 1$

Operation060: $m_p = \frac{9,8}{5} = 1,96$ $m_n = 2$

Further counting equipment load factor on operations:

$$\eta_{з005} = \frac{0,6}{1} = 0,5; \eta_{з010} = \frac{0,2}{1} = 0,2; \eta_{з015} = \frac{0,2}{1} = 0,0 = 2.$$

$$\eta_{з020} = \frac{0,8}{1} = 0,8; \eta_{з025} = \frac{0,6}{1} = 0,6; \eta_{з030} = \frac{0,5}{1} = 0,5.$$

$$\eta_{з035} = \frac{1,02}{2} = 0,51; \eta_{з040} = \frac{1,2}{2} 0,6; \eta_{з045} = \frac{0,2}{1} = 0,2.$$

$$\eta_{з050} = \frac{0,14}{1} = 0,14; \eta_{з055} = \frac{0,4}{1} = 0,4; \eta_{з060} = \frac{1,96}{2} = 0,98.$$

Using the tools of power.

This factor is characterized by the coefficient using equipment η_M that is the ratio of required power to drive N_{np} Machine to power the electric motor installed N_{cm}:

$$\eta_M = \frac{N_{np}}{N_{cm}}$$

Thus,

$$\eta_{M005} = \frac{3,4}{10} = 0,34; \eta_{M010} = \frac{1,5}{7,5} = 0,2; \eta_{M015} = \frac{1,2}{4} = 0,3.$$

$$\eta_{M020} = \frac{4,8}{7,5} = 0,64; \eta_{025} = \frac{2,7}{7} = 0,4; \eta_{M030} = \frac{2,5}{7} = 0,36.$$

$$\eta_{M050} = \frac{4,3}{7,5} = 0,6; \eta_{M055} = \frac{2,3}{4} = 0,57; \eta_{M060} = \frac{4,5}{7,5} = 0,9.$$

The utilization of main equipment (technology) indicates a time share computer time in the total time of the machine. It is defined as the ratio of normal time to artificially - calculation of time:

$$\eta_0 = \frac{T_0}{T_{ш.к}}$$

Thus, for each operation calculate η_0:

$$\eta_{0005} \frac{4,9}{5,745} = 0,85; \quad \eta_{0010} = \frac{0,33}{0,735} = 0,45; \eta_{0015} = \frac{0,48}{1,032} = 0,47.$$

$$\eta_{0020} = \frac{6,54}{7,235} = 0,9; \eta_{0025} = \frac{8,96}{10,21} = 0,9; \eta_{0030} = \frac{9,6}{10,37} = 0,92.$$

$$\eta_{0035} = \frac{1,16}{3,042} = 0,4; \eta_{0040} = \frac{0,64}{2,7} = 0,24; \eta_{0045} = \frac{0,2}{0,91} = 0,22.$$

$$\eta_{0050} = \frac{0,62}{1,524} = 0,41; \eta_{0055} = \frac{1,23}{2,07} = 0,6; \eta_{0060} = \frac{2,23}{2,93} = 0,8.$$

If the graph shows that the machine is under loaded by a particular parameter, it loadable input to a processing machine under loaded one or more additional components to be processed.

3. DESIGN CHAPTER

One indicator of the cost - efficient production preparation is reducing the complexity and timing of all preparatory cycle, the bulk of which in manufacturing engineering involves design, fabrication and special adjustment of technological equipment.

These requirements largely depend on the composition and number of machine devices that are consuming most types of equipment. They should be chosen taking into account the specific conditions of production prepared.

3.1. Development of special machine design and control devices of technological equipment.

3.1.1. Structure and principle of the device for fixing parts in modular machine tools.

Accessories for modular machine tools (operation 60) intended for fixing the housing part "body" 714252.004.

Accessories set 6 - positional adjustable - dividing machine 6, designed to move parts from one position to another and fixing cam 15 at each position by means of sealing pressure 20.

By turning the faceplate (24), under the guide of lubrication stations served with a certain oil pressure (hydrostatic lubrication).

Fixed and jammed in the adaptation piece is consistently working position of the table, on which conducted its processing tool set and enshrined in law in the spindle head. The full cycle of processing performed by one turn adjustable faceplate - a ruling table 2.6.

Clip and print details, and its fixing and fixing roses conducted on boot with fixed position rotary table faceplate.

Management clamping mechanism is worked out using the buttons on the remote.

Sam machine - aggregate - is 5 - third parties 17 - spindle drilling - threading 6 - positional turntable.

The machine is made:

– drilling 4 holes ∅6,7H12; drilling ∅14,5H12;
– drilling 2 holes ∅18,25H12,
– threading KG 1 / 2’’ (∅19,772) 2 holes; threading M16h1,5-7H;
– threading M16-7H3 holes;
– threading M8-7H in 4 holes.

3.1.2. Selection of the installation part in aggregate adjustment.

This scheme settings on the outer cylindrical surface allows treated ($\varnothing 170\frac{H7}{f7}$) process all sides and surface details for processing involved in this operation. Also setting is on two different ends of the parts, providing clear guidance for details of this operation.

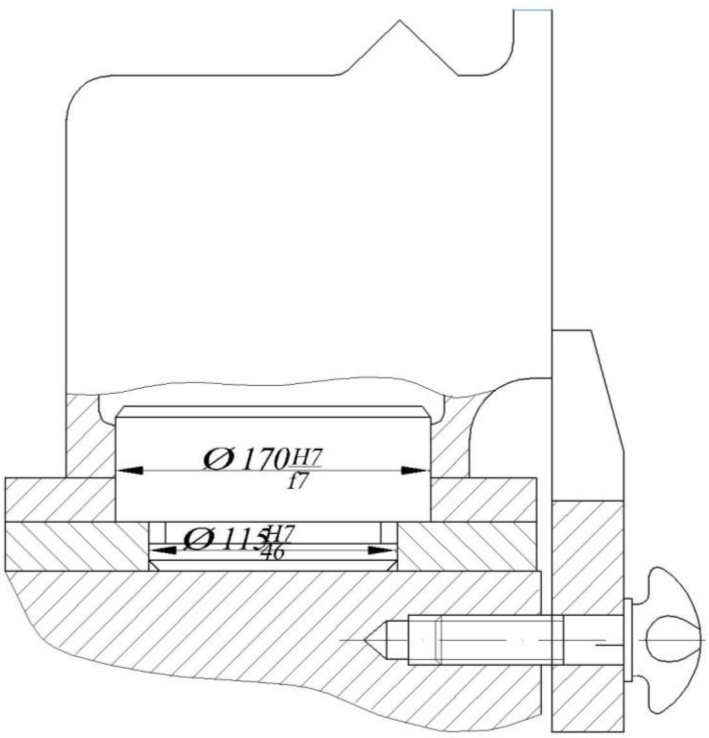


Figure 3.1 - Apparatus detail in the aggregate adjustment

3.1.3. Calculation of errors of installing parts in the aggregate adjustment.

Installation error, as one of the components of the overall executable size error, error of basing summing $\xi_б$, fixing $\xi_з$. In its physical sense expresses the value of $\xi_б$=0 [1] position error of the workpiece.

So, choose a deployment error:

$$\xi = \sqrt{\xi_б^2 + \xi_з^2};$$

$$\xi = \sqrt{0^2 + 110^2} = 110 mkm.$$

There are also provisions error of part, but in this adaptation of processing and accuracy is not affected (drilled holes), as per it's not take into account.

3.1.4. Determining the required clamping force for the aggregate adjustment.

Calculation of the clamping force in the design of new devices: You need to know the projected processing conditions - size, direction and location of application of forces by shifting the workpiece and scheme of installation and fixing.

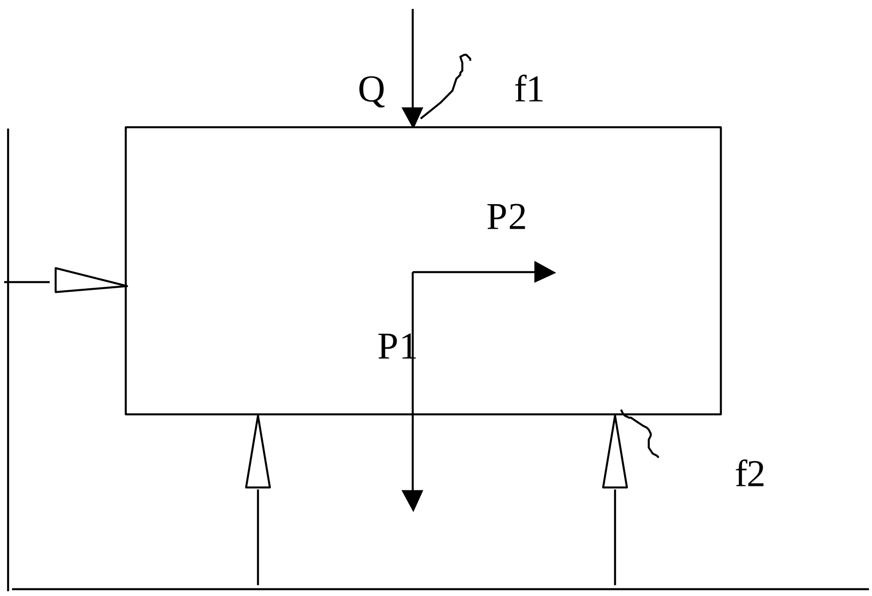


Figure 3.2 - The scheme for calculating the clamping force

By manufacturing billets applied forces that arise during processing, the desired reaction force and support. Under the influence of these forces the workpiece is in equilibrium.

Power consolidation should be sufficient to prevent bias in the adaptation set piece.

To do this, select the default scheme for calculating the forces clamping workpieces of displacement.

In this scheme since $f_1=f_2=f$- coefficient of friction, then the clamping force will be reported by the formula:

$$Q = \frac{KP_z}{f_1 + f_2} = \frac{1,5*59}{0,78+0,78} = 56,7;$$

where K - factor of safety; K = 1,5 [12];

$f_1 = f_2 = 0,78$;

P_z - the force acting on the workpiece during the cutting process.

3.1.5. Selection of the type clamping unit for the aggregate adjustment.

For these pneumatic devices, under certain parameters it determines the type clamping device.

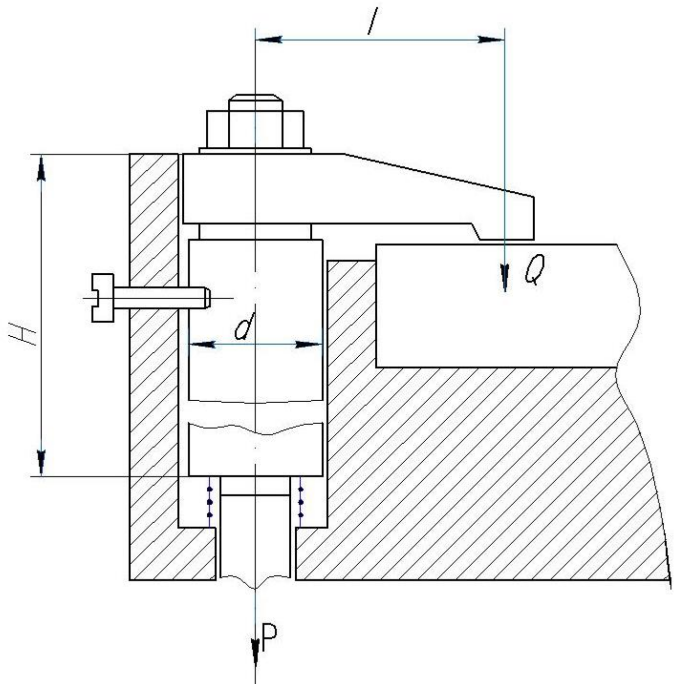


Figure 3.3 - Scheme typical clamping device

The unit represented with D - shaped clamps, which is very suitable for these machining parts for modular machine.

Dimensions driveline will depend on several factors, including the size of workpiece size, strength fastening material of power components, parameters ofnes the type clamping device.

Efforts to clamp nightingale specific type of device:

$$Q = P(1 - \frac{3\ell}{H} f)\text{, kg;}$$

where ℓ - distance from the axis to the point of applied force; ℓ =55 mm;
H – the height of the guide; H=275 mm;
f – friction; f=0,781;
d – the diameter of the guide; d=35 mm.

$$Q = 59(1 - \frac{3\ell}{H} f) = 59(1 - \frac{3*55}{275} 0,781) = 57,05N.$$

3.1.6. Description of construction machine tool accessories for diamond boring operation.

Diamond boring adjustment for finishing holes in the part, consists of a body 3 on which is fixed to the cylinder 2, and for founding the plate 8 with three fingers which is based the workpiece. Using the rod cylinder sleeve 7 is mounted, and the bush planted at a steady 1 of 5 spinning cycle.

The adjustment works on the principle of the lever when the cylinder rod moves down, it entails a sleeve stable and on cycle of spinning thereby firmly pressed to the plate and produces machining on a lathe. After processing cylinder rod moves in the opposite direction (upward) after which the processing releases press a part.

The adjustment is productive because it has two sided press plate and thus can treat two parts simultaneously.

3.1.7. Calculation of basing errors and force clamping device for diamond boring machining.

The error count deployment of the formula:

$$\xi = \frac{\Delta}{2} = \frac{0.2}{2} = 0{,}1\text{mm}.$$

The scheme is similar clamping scheme in [9].

Power clamp that is needed to clamp the details:

$$W=5kP=5{,}1*1{,}40*5{,}92=41{,}4 \text{ N},$$

k - factor of safety; k = 1,40;

P - the force acting on the workpiece during processing; P = 5,92 N.

The force which can develop stem cylinder:

$$Q = (\pi D^2/4)\,p\eta,$$

where D - diameter cylinder, mm;

p - oil pressure 20-75 kgf/mm^2;

$$\eta - 0{,}86\text{-}0{,}92.$$

$$Q = (3{,}14*20^2/4)25^2*0{,}86 = 70{,}8 \text{ N}.$$

3.1.8. Design of a special device for controlling adjustment.

Device for controlling alignment holes ∅120N7 of the part.

How it works:

To control the alignment must set adjustment hole controlled. Indicator set to "0", then rotate part 180 and run indicator.

The difference shows indicators that obtained in 2 opposite areas divided by half, give access alignment holes.

Detail is considered suitable if the value of tolerance alignment is no more 0,03 mm.

Breathing consists of a body 3 which is under spring plunger that rests on parts. In the body twists the handle 1 housing unit is attached to the bracket 4 screws 6 at the second end bracket mounted LED watch type, in which both measures the displays deviations. His leg rests on the wall opposite the hole and controls parameter alignment of two holes.

3.2. Design of special cutting tools.

The construct special cutting tools - boring cutter plate carbide BK8.

Material machining surfaces Ra 2,5 micron. Cutter is designed to work on diamond - boring.

Solution: choose the type of boring tool and geometrical parameters on GOST 9795-87; φ=90^0, $\varphi_1 = 50^0$, £=15^0; $\gamma = 0^0$; $\lambda = -3^0$.

Material of the tool holder - steel hardness 45 HRC35-40.

The dimensions of the tool GOST 3787-75.

Technical requirements GOST 13297-76 cutters:

A) Not specified tolerances sizes h14, $\pm \frac{IT14}{2;}$.

B) Tolerance for all angles ±1.

C) Solder plate ПрМНМц 68-4-2,

TU 48-08-476-71.

Special in this cutting tool is its irregular shape section and slightly modified of cutting to improve cleanliness and accuracy.

4. SAFETY MEASURES

4.1. Importance of labor protection.

Workplace safety is very important for each and every employee in the industry because all the workers desire to work in a safe and protected atmosphere. Health and safety is the key factor for all industries in order to promote the wellness of both employees and employers. It is a duty and moral responsibility of the company to look after the employee’s protection.

All the industries do have safety risks but the management should devote their time to think and strategize the things that what safety precautions are required in their company to make sure that their workers are safe enough for all the time. Also, the management should confirm with all the workers related to their daily work and comfort. So, that the management can take the same step according to the desired aspects of workers. This helps them in improving the productivity and quality of the products and lot more.

Safety is one of the biggest issue and it is completely the responsibility of the managers and the business owners to make sure that their employees are working in a safe environment or not. The management should make sure that they keep on motivating and boosting the employees to make them active in the working process. One of the safety devices is a weak link, that is, a component or a node that is designed to break or not overload. These parts include: cutting pins and joints, friction clutches, smooth fuses, discontinuous membranes. Activation of the weak link leads to the machine stopping in emergency modes, which eliminates breakdowns, damage and, consequently, injuries.

4.2. Electrical safety precautions.

Electric machines and power electronics experiments involve electrical currents, voltages, power, and energy quantities that should be handled with extreme diligence and care. The "Safety Precautions" procedural section covers the major guidelines and precautions intended to achieve a safe lab and operating environment for people performing experiments. These guidelines are by no means inclusive of all necessary precautions, and local electrical safety rules and regulations should be followed.

Experiments involving electric machines and power electronics typically use common equipment to supply power and to measure electrical quantities. However, circuits and apparatus being tested vary for different experiments. The "Basic Equipment" procedural section provides an overview of major equipment used for most electric machines and power electronics experiments. Specific equipment, circuits, and apparatus are introduced in each experiment as needed.

Electric power and experimental setup.

1. Avoid loose wires, cables, and connections. Assume any exposed metal is live with electricity unless otherwise verified.

2. Familiarize oneself with all ON/OFF buttons on equipment, circuit breakers, and disconnect switches of a bench.

3. Only make changes to the experimental setup when the circuit power is turned off and all power sources read zero voltage and zero current, as applicable.

4. Use wires of suitable length for their appropriate applications. Long wires or connections can cause clutter on a bench, and very short wires or connections can be too tight and may be easily disconnected.

5. Separate higher power equipment and connections from lower power equipment, such as microcontrollers, to avoid both interference and electrical interconnections between sensitive electronic devices and higher power devices.

6. Make sure that all DC power supplies, AC sources, and other power sources start from a zero voltage and zero current output or as directed in an experiment. Starting from a non-zero voltage is possible in certain applications where a voltage source should have a specific initial condition.

7. Turn off all equipment before leaving the lab once an experiment concludes.

8. Do not allow a single user to perform an experiment alone. Make sure at least two users perform an experiment when operating more than 50 V DC and three-phase AC.

4.3. The basic principles of policy in the field of labor protection.

Working conditions in the workplace, safety of technological processes, machines, mechanisms, equipment and other means of production, state of collective and individual protection used by the employee and sanitary conditions must meet the requirements of the legislation.

The employee has the right to refuse the assigned work, if the production created a situation dangerous to his life or health or for the people who surround him, or for a production environment or the environment. The right of workers to benefits and compensation for heavy and harmful working conditions.

Workers employed in jobs with difficult and harmful working conditions, free of charge are provided with healthful and dietary meals, milk or equivalent food, soda salt water, are entitled to paid breaks sanitary and health purposes, reduced working hours, additional paid leave, reduced pensions, wages at a higher rate and other benefits and compensation provided in accordance with the law.

Providing employees with special clothing, other means of individual protection, detergents or neutralizing agents. On works with dangerous working conditions, and pollution or adverse weather conditions, employees are issued free of charge for the established rules of special clothes, footwear and other personal protective equipment, cleaning and neutralizing means. Compulsory medical examinations of workers of certain categories. The employer is obliged to provide funding and to organize preliminary (during the hiring) and periodic (during labour activity) medical examinations of workers employed in heavy works, works with harmful or dangerous working conditions or such where there is a need for professional selection.

According to the results of periodic medical examinations, if necessary, the employer must provide appropriate health measures. The employer is obliged to provide at their own expense, an extraordinary medical examination of employees:

- at the request of the employee, if he believes that the deterioration of his health related to working conditions;

- on its own initiative, if the health worker does not allow him to perform their duties.

CONCLUSION

In the diploma project, an improved technology for the production of the "body" 714252.004 is proposed. After a detailed analysis of the basic technological process, changes were made regarding the introduction of a rational method of obtaining the workpiece, the scheme of basing the part on the vertical drilling operation was changed, which made it possible to reduce the number of readjustments and tool changes.

The total number of machining operations has been reduced due to the concentration of operations. For this purpose, the design of a special aggregate device was developed, accuracy calculations were performed, part positioning errors were determined, the accuracy of machining processes and the quality of machining parts were increased. The use of special control devices is proposed, their designs and principle of operation are described.

The amount of necessary equipment was determined, the cutting modes were calculated, the normalization of operations was carried out, and the project version of the technological route was developed.

Changes have been made regarding the use of cutting and measuring tools, the design of the cutting tool has been developed in order to increase the accuracy of processing and the speed of forming surfaces, as well as to reduce the total time spent on cutting operations.

Attention is paid to safety issues related to the use of electrical equipment and its safe operation.

Innovation proposals allow to increase the productivity of the body manufacturing process, reduce the number of equipment, production areas and workers. Recommendations on the use of the obtained technical solutions in the manufacturing technology of similar typical parts have been developed.

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