Ministry of Education and Science of Ukraine
Ternopil Ivan Puluj National Technical University
(full name of higher education institution)
Faculty of Engineering of Machines, Structures and Technologies
(faculty name)
Engineering technology
(full name of department)

EXPLANATORY NOTE

for diploma project (thesis)

Bachelor
(educational level)

topic: *Improving the technological process of machining parts body 00.01.004*

Submitted by: fourth year student group ІМП-42
Specialism (field of study)
131 Mechanics Engineering
(code and name of specialism (field of study))
(signature) *Kanna Ravi Ragu* (surname and initials)

Supervisor (signature) *Pankiv M.R.*

Standards verified by (signature) *Dyachun A.Y.* (surname and initials)

Referee (signature) (surname and initials)

Ternopil
2022

Ministry of Education and Science of Ukraine
Ternopil Ivan Puluj National Technical University

Faculty *Faculty of Engineering of Machines, Structures and Technologies*
(full name of faculty)

Department *Engineering technology*
(full name of department)

APPROVED BY
Head of Department
______________ *Okipnyy Ihor*
(signature) (surname and initials)
« 2 » 02 2022 р

ASSIGNMENT

for QUALIFYING PAPER

for the degree of *bachelor*

specialty *131 Mechanics Engineering*
(code and name of the specialty)

student *Kanna Ravi Ragu*
(degree name)

1. Paper topic *Improving the technological process of machining parts body 00.01.004.*

Paper supervisor *Pankiv Maria, Ph.D., Associate Professor*
(surname, name, patronymic, scientific degree, academic rank)

Approved by university order as of «*31* » *12* *2022* № *4/7-1178*

2. Student's paper submission deadline *14.06.2022*

3. Initial data for the paper *. Basic TP manufacturing parts. The program is 55 0000 pcs. Drawing the body part.*

4. Paper contents (list of issues to be developed)
Abstract. Content. Introduction. General technical part. Technological part. Design part. Life safety, basics of labor protection. Conclusions. References.

5. List of graphic material (with exact number of required drawings, slides)
Workpiece; Technological adjustment ; Milling device; Control and measuring device.

6. Advisors of paper chapters

Chapter	Advisor's surname, initials and position	Signature, date	
		assignment was given by	assignment was received by
Life safety and basics of labor protection	*Lazaryuk Valeriy, Ph.D., Associate Professor*		

7. Date of receiving the assignment ____________________

TIME SCHEDULE

LN	Paper stages	Paper stages deadlines	Notes
	Abstract	*14.06.2022*	
	Content	*14.06.2022*	
	Introduction	*11.02.2022*	
	General technical part	*11.02.2022*	
	Technological part	*06.06.2022*	
	Design part	*06.06.2022*	
	Life safety, basics of labor protection	*11.06.2022*	
	Conclusions	*14.06.2022*	
	References	*14.06.2022*	
	Graphic part	*14.06.2022*	

Student ____________ *Kanna Ravi Ragu*
(signature) (surname and initials)

Paper supervisor ____________ *Pankiv Maria*
(signature) (surname and initials)

INTRODUCTION

Mechanical engineering is the leading link in the industry. In modern mechanical engineering, cutting is the main technological method that ensures high quality and precision of machined surfaces of parts.

Mechanical engineering is becoming increasingly important today. This is the basis of our future prosperity, a guarantee that Ukraine will in the future become a developed industrial state.

An increase in the output of engineering products should take place at the same time as improving its quality. Currently, there is a complication of the design of machines and mechanisms, which is caused by increasing requirements for reliability, durability of mechanisms.

CONTENT

ABSTRACT

In the explanatory note the general technical part deals with the analysis of the manufacturability of the product, its purpose, the characteristics of possible production, the analysis of the use of technical means, the conclusions and the problem statement for the thesis.

In the technological part, a preliminary installation of the production type with respect to a given program was carried out, variants of a possible technical process were developed, and optimal technological processes were developed based on the analysis of the technical properties of the basic capabilities of the part. Practical calculations of cutting modes, technical time norms, on the basis of which operational maps of technological debugging were developed.

1. GENERAL TECHNICAL PART

1.1Purpose and characteristics of the object of production

Part - the case is made of steel CT 45Л by casting in the chill mold, so the configuration of the outer case and inner surfaces does not cause significant difficulties in obtaining the workpiece. But even under the above conditions, molding should be carried out using rods with which holes are formed. These elements are determined by constructive considerations and it is impractical to change them.

Table 1.1 - Chemical composition of the part 45Л

Material	C,%	Ni,%	Mn,%	S.%	Cr,%
Steel 45Л	0,45	0.2-0.52	0.4-0.9	0.045	0.3

Table 12 - Mechanical properties of steel 45Л

Temperature C°		σт	σв	S_5	ψ	HB
Normalization	Tempering	%	%	%	%	МПа
360-880	600-300	280	500	15	25	160

Qualitative assessment of manufacturability. In this design, the groove 12h7 is not technological. It must be made to an accuracy of 7 quality, and adjacent surfaces are processed to 9 quality, which leads to some inconvenience in setting up the tool.

Also inconvenient from the point of view of manufacturability is a fastening opening of Ø10 mm. The process of bringing the tool to the surface is somewhat complicated.

On the other hand, the part is quite technological, has good base surfaces for priority operations. The location of the mounting holes allows a lot of tooling.

Quantitative assessment of manufacturability.

Unification coefficient:

$$К_{ун.ел.} = \frac{Q_{ун.ел}}{Q_{заг.ел.}} > 0,6$$

where $Q_{ун.ел.}$ – the number of unified elements of the part ($Q_{ун.ел}$ = 32 pcs.)

$Q_{заг.ел}$. – the total number of elements of the part ($Q_{заг.ел.}$ = 35 pcs.)

$$К_{ун.ел.} = \frac{32}{35} = 0{,}914 > 0{,}6 \Rightarrow \text{detail is technological.}$$

Surface accuracy factor:

$$К_{т.п.} = 1 - \frac{1}{Тсер.} > 0{,}8 \qquad (1.1)$$

$$Т_{сер}. = \frac{(\Sigma Ti \times ni)}{\Sigma ni},$$

where T_i – quality of surface treatment accuracy;

n_i – the number of surfaces treated according to this quality.

Table 1.3 - Calculation of quantitative assessment

Ti	ni	Ti×ni
H12	10	120
H10	2	20
H9	12	108
H8	4	32
H7	1	7

$$Т_{сер}. = \frac{(120+20+108+32+7)}{(10+2+12+4+1)} = 9{,}4$$

$$К_{т.п} = 1 - \frac{1}{9{,}4} = 0{,}9 > 0{,}8 \Rightarrow \text{detail is technological}$$

Coefficient of surface roughness:

$$К_{ш.п.} = \frac{1}{Мсер.} < 0{,}32$$

$$М_{сер}. = \frac{(\Sigma Mi \times ni)}{\Sigma ni}, \qquad (1.2)$$

where M_i – roughness of a processing surface, *Ra*;

n_i – the number of machining surfaces.

Table 1.4 - Calculation of quantitative assessment

Mi	ni	Mi×ni
20	2	40
10	9	90
2,5	7	17,5
1,25	2	2,5
0,63	1	0,63

$$\text{М}_{\text{сер}}.=\frac{(40+90+17.5+2.5+0.63)}{(2+9+7+2+1)}=6.42$$

$$\text{К}_{\text{ш.п}}.=\frac{1}{6,42}=0,156<0,32 \Rightarrow \text{detail is technological}$$

Material utilization factor:

$$\text{К}_{\text{в.м.}}=\frac{M\partial}{M\text{заг.}} \qquad (1.2)$$

where M_{∂} – mass of details ($M\partial$ = 3,74)

$M_{заг}$. – mass of the workpiece ($\text{М}_{\text{аг}}$.=4,3 kg)

$$K_{в.м}.=\frac{3,74}{4,3}=0,869$$

The part is technological because it satisfies all the conditions imposed on it.

1.2 Analysis of the basic (typical) technological process

The existing technological process of manufacturing the part involves the manufacture of the workpiece part by casting. Technological process of machining is characterized by the classical scheme of the technological route - processing on the first operation of the technological base - surface B - and on this basis processing of other surfaces.

005 Milling operation

1. Mill the surface 1 roughly
2. Mill surface 1 semi-clean

010 Milling operation

1. Mill the surface 2 roughly
2. Mill the surface 3 roughly

015 Milling operation

1. Mill by a set of cutters surface 6, 7, 8 rough
2. Mill by a set of cutters surface 6, 7, 8 semi-clean

020 Milling operation

1. Mill by a set of cutters surface 4, 5, 9, 10 rough
2. Mill by a set of cutters surface 4, 5, 9, 10 semi-clean

025 Boring operation

1. Grind the surface 11 roughly
2. Grind the surface 12 roughly
3. Drill a groove 13 formation of ends 14 and 15 roughly
4. Grind grooves 16 simultaneously rough
5. Grind the surface 17 roughly

030 Boring operation

1. Grind the surface 11 clean
2. Grind the surface 12 clean
3. Grind grooves 16 clean at the same time
4. Expand surface 17 cleanly

035 Aggregate operation

1. Drill 2 holes with a diameter of 5 through
2. Drill 2 holes with a diameter of 10 and a length of 12 mm
3. Counter 2 holes with a diameter of 5 through
4. Counter 2 holes with a diameter of 10 and a length of 12 mm
5. Cut a thread 2 holes M5-7H through
6. Cut a thread 2 holes M10-7H 12 mm long

040 Aggregate operation

1. Drill 4 holes with a diameter of 8 and a length of 12 mm
2. Drill 2 holes 5 with a diameter of 12 mm
3. Counter 4 holes with a diameter of 8 and a length of 12 mm
4. Countersink 2 holes 5 with a diameter of 12 mm
5. Expand 2 holes with a diameter of 5 and a length of 12 mm
6. Cut a thread 4 holes M8-7H 12 mm long

045 Aggregate operation

1. Drill a hole with a diameter of 5 through
2. Drill a hole with a diameter of 12 and a length of 3 mm
3. Countersink the hole with a diameter of 6 through
4. Countersink a hole 12 with a diameter of 3 mm
5. Cut the M6-7H cut through

050 Milling operation

1. Mill groove 18 roughly
2. Mill groove 18 semi-clean
3. Mill the groove 18 finely

055 Diamond boring operation

1. Grind the surface 11 thinly
2. Grind the surface 17 thinly

Milling of a detail is carried out on the vertical milling machine 6P12 which completely approaches dimensions for processing of the given detail and provides the corresponding accuracy.

Processing of holes for mounting is performed on a vertical drilling machine 2M55 by sequential drilling of 2 holes with subsequent countersinking.

Drilling and milling operations are characterized by high basic and auxiliary time and significant manual labor costs.

The equipment of the basic technological process is selected in accordance with the requirements for power and dimensions.

Technological equipment of operations requires partial improvement through the use of high-speed clamping mechanisms, multi-tool machining, the use of advanced cutting tools.

1.4 Conclusions and setting tasks for qualifying work

Thus, having analyzed the factory version of the TP machining of the housing we conclude that it is appropriate to modernize the existing process. This modernization is as follows:

1) change in the structure of the technological process;
2) the choice of optimal, in terms of minimum cost and maximum productivity, process equipment;
3) the choice of the workpiece with the minimum cost of production;
4) the choice of technological equipment to increase productivity and reduce the cost of processing.

2. TECHNOLOGICAL PART

2.1 Characteristics of the type and organizational form of production

Initial data for determining the type of production:

Annual program of production of details N = 35000 pieces.

Actual annual time fund of equipment of average repair complexity at two-shift work – $F_д$ = 3938 h.

$$F_{\partial} = 4190 - (4190 \times 0,06) = 3938 \text{ год.}$$

Nominal fund for two-shift work – $F_н$ = 4190 h; costs 6%

The type of production is characterized by the coefficient of consolidation of operations:

$$K_{з.о.} = \frac{\Sigma O}{\Sigma P} \tag{2.1}$$

where ΣO - the number of all operations that can be performed at the site

ΣP - number of jobs at the site.

$$O = \frac{\eta з.норм}{\eta з.факт.} \tag{2.2}$$

where $\eta з.норм.$ - normative factor of loading of the equipment (we accept equal 0,85)

$\eta з.факт.$ - the actual load factor of the equipment

$$\eta з.факт. = \frac{P_{розр.}}{P_{пр.}} \tag{2.3}$$

where $P_{розр.}$ – estimated amount of required equipment;

$P_{пр.}$ – accepted the amount of necessary equipment.

$$P_{розр.} = \frac{T_{шт.к.} \times N}{60 \times Fg \times \eta з.норм.} \tag{2.4}$$

where $T_{шт.к.}$ – artificial calculation time for the operation, min.

To determine the organizational form of production it is necessary to compare the average rate of time Тшт.сер. with the estimated release rate Тв:

$$K_з = \frac{Тшт.сер.}{Тв} \tag{2.5}$$

Determine the artificial time for operations by the formula:

$$Тшт. То \times \varphi, \tag{2.6}$$

where To – basic technological time;

φ – coefficient depending on the type of production.

The basic technological time is determined for each technological transition.

005 Milling operation

1. Mill the surface 1 roughly

$$To = 7 \times L = 7 \times 210 \times 10^{-3} = 1,47 (хв)$$

2. Mill surface 1 semi-clean

$$To = 4 \times L = 4 \times 210 \times 10^{-3} = 0,84 (хв)$$

$$\Sigma To = 2,31 (хв)$$

$$Тшт.к. = 2,31 \times 1,51 = 3,49 (хв.),$$

where φ = 1,51 (for large-scale production for milling operation)

010 Milling operation

1. Mill the surface 2 roughly

$$To = 7 \times L = 7 \times 20 \times 10^{-3} = 0,14 (хв.)$$

2. Mill the surface 3 roughly

$$To = 7 \times L = 7 \times 20 \times 10^{-3} = 0,14 (хв.)$$

$$\Sigma To = 0,28 (хв.)$$

$$Тшт.к. = 0,28 \times 1,51 = 0,423 \ (хв.)$$

015 Milling operation

1. Mill by a set of cutters surface 6, 7, 8 rough

$$To = 7 \times L = 6 \times 105 \times 10^{-3} = 0,735 (хв.)$$

2. Mill by a set of cutters surface 6, 7, 8 semi-clean

$$To = 4 \times L = 4 \times 105 \times 10^{-3} = 0,42 (хв.)$$

$$\Sigma To = 1,155 (хв.)$$

$$Тшт.к = 1,155 \times 1,51 = 1,744 (хв.)$$

020 Milling operation

1. Mill by a set of cutters surface 4, 5, 9, 10 rough

$$To = 7 \times L = 7 \times 67 \times 10^{-3} = 0,469 (хв.)$$

2. Mill by a set of cutters surface 4, 5, 9, 10 semi-clean

$$To = 4 \times \mathrm{L} = 4 \times 67 \times 10^{-3} = 0,268\left(\textit{хв.}\right)$$

$$\Sigma To = 0,737\left(\textit{хв.}\right)$$

$$T\textit{шт.к.} = 0,737 \times = 1,11\left(\textit{хв.}\right)$$

025 Boring operation

1. Grind the surface 11 roughly

$$To = 0,3 \times \mathrm{d} \times \mathrm{L} = 0.3 \times 35 \times 25 \times 10^{-3} = 0,625\left(\textit{хв.}\right)$$

2. Grind the surface 12 roughly

$$To = 0,3 \times \mathrm{d} \times \mathrm{L} = 0.3 \times 20 \times 27 \times 10^{-3} = 0,62\left(\textit{хв.}\right)$$

3. Grind the groove 13 with the formation of the ends 14 and 15 roughly

$$To = 0,2 \times \mathrm{d} \times \mathrm{L} = 0.2 \times 35,5 \times 3 \times 10^{-3} = 0,0213\left(\textit{хв.}\right)$$

4. Grind grooves 16 simultaneously rough

$$To = 0,3 \times \mathrm{d} \times \mathrm{L} = 0.3 \times 25 \times 3,7 \times 10^{-3} = 0,0278\left(\textit{хв.}\right)$$

5. Grind the surface 17 roughly

$$To = 0,3 \times \mathrm{d} \times \mathrm{L} = 0.3 \times 50 \times 30 \times 10^{-3} = 0,45\left(\textit{хв.}\right)$$

$$To = 0,9236\left(\textit{хв.}\right)$$

$$T\textit{шт.к} = 0,9236 \times 1.41\left(\textit{хв.}\right)$$

030 Boring operation

1. Grind the surface 11 semi-clean

$$To = 0,3 \times \mathrm{d} \times \mathrm{L} = 0.3 \times 35 \times 25 \times 10^{-3} = 0,2625\left(\textit{хв.}\right)$$

2. Grind the surface 12 semi-clean

$$To = 0,3 \times \mathrm{d} \times \mathrm{L} = 0.3 \times 20 \times 27 \times 10^{-3} = 0,162\left(\textit{хв.}\right)$$

3. Grind grooves 16 clean at the same time

$$To = 0,3 \times \mathrm{d} \times \mathrm{L} = 0.3 \times 25 \times 3,7 \times 10^{-3} = 0,0278\left(\textit{хв.}\right)$$

4. Grind the surface 17 roughly

$$To = 0,3 \times \mathrm{d} \times \mathrm{L} = 0.3 \times 50 \times 30 \times 10^{-3} = 0,45\left(\textit{хв.}\right)$$

$$To = 0,91\left(\textit{хв.}\right)$$

$$T\textit{шт.к.} = 0,91 \times 1,41 = 1,29\left(\textit{хв.}\right)$$

035 Aggregate operation

1. Drill 2 holes with a diameter of 5 through

$$To = 2\times 0,52\times \mathrm{d}\times \mathrm{L} = 2\times 0,52\times 5\times 9\times 10^{-3} = 0,047(\text{хв.})$$

2. Drill 2 holes with a diameter of 10 and a length of 12 mm

$$To = 2\times 0,52\times \mathrm{d}\times \mathrm{L} = 2\times 0,52\times 10\times 12\times 10^{-3} = 0,125(\text{хв.})$$

3. Counter 2 holes with a diameter of 5 through

$$To = 2\times 0,21\times \mathrm{d}\times \mathrm{L} = 2\times 0,21\times 5\times 9\times 10^{-3} = 0,0504(\text{хв.})$$

4. Counter 2 holes with a diameter of 10 and a length of 12 mm

$$To = 2\times 0,21\times \mathrm{d}\times \mathrm{L} = 2\times 0,21\times 5\times 9\times 10^{-3} = 0,0504(\text{хв.})$$

5. Cut 2 holes M5-7H through

$$To = 2\times 0,4\times \mathrm{d}\times \mathrm{L} = 2\times 0,4\times 5\times 12\times 10^{-3} = 0,048(\text{хв.})$$

6. Cut 2 holes M10-7H 12 mm long

$$To = 2\times 0,4\times \mathrm{d}\times \mathrm{L} = 2\times 0,4\times 10\times 12\times 10^{-3} = 0,096(\text{хв.})$$

$$To = 0,125(\text{хв.})$$

$$Тит.к. = 0,125\ \times 1,3 = 0,1625(\text{хв.})$$

where φ = 1,3 (for drilling operations)

040 Aggregate operation

1. Drill 4 holes with a diameter of 8 and a length of 12 mm

$$To = 4\times 0,52\times \mathrm{d}\times \mathrm{L} = 4\times 0,52\times 8\times 12\times 10^{-3} = 0,1997(\text{хв.})$$

2. Drill 2 holes 5 with a diameter of 12 mm

$$To = 2\times 0,52\times \mathrm{d}\times \mathrm{L} = 2\times 0,52\times 5\times 12\times 10^{-3} = 0,0624(\text{хв.})$$

3. Counter 4 holes with a diameter of 8 and a length of 12 mm

$$To = 4\times 0,21\times \mathrm{d}\times \mathrm{L} = 4\times 0,21\times 8\times 12\times 10^{-3} = 0,081(\text{хв.})$$

4. Countersink 2 holes 5 with a diameter of 12 mm

$$To = 2\times 0,21\times \mathrm{d}\times \mathrm{L} = 2\times 0,21\times 5\times 12\times 10^{-3} = 0,025(\text{хв.})$$

5. Deploy 2 holes 5 with a diameter of 12 mm

$$To = 2\times 0,52\times \mathrm{d}\times \mathrm{L} = 2\times 0,52\times 5\times 12\times 10^{-3} = 0,0624(\text{хв.})$$

6. Cut a cut of 4 holes M8-7H 12 mm long

$$To = 4\times 0,4\times \mathrm{d}\times \mathrm{L} = 4\times 0,4\times 8\times 12\times 10^{-3} = 0,154(\text{хв.})$$

$$To = 0,1997(\text{хв.})$$

$$Тит.к. = 0,1997\times 1,3 = 0,2596(\text{хв.})$$

where φ = 1,3 (for drilling operations)

045 Aggregate operation

1. Drill a hole with a diameter of 6 through

$$To = 0,52 \times \mathrm{d} \times \mathrm{L} = 0,52 \times 6 \times 10 \times 10^{-3} = 0,031(\text{хв.})$$

2. Drill a hole with a diameter of 12 and a length of 3 mm

$$To = 0,52 \times \mathrm{d} \times \mathrm{L} = 0,21 \times 12 \times 3 \times 10^{-3} = 0,0187(\text{хв.})$$

3. Drill a hole with a diameter of 12 and a length of 3 mm

$$To = 0,21 \times \mathrm{d} \times \mathrm{L} = 0,21 \times 6 \times 10 \times 10^{-3} = 0,0126(\text{хв.})$$

4. Countersink a hole 12 with a diameter of 3 mm

$$To = 0,21 \times \mathrm{d} \times \mathrm{L} = 0,21 \times 12 \times 3 \times 10^{-3} = 0,0076(\text{хв.})$$

5. Cut the M6-7H cut through

$$To = 0,4 \times \mathrm{d} \times \mathrm{L} = 0,4 \times 6 \times 12 \times 10^{-3} = 0,029(\text{хв.})$$

$$To = 0,031(\text{хв.})$$

$$T\text{шт.к.} = 0,031 \times 1,51 = 0,047(\text{хв.})$$

050 Milling operation

1. Mill groove 18 roughly

$$To = 7 \times \mathrm{L} = 7 \times 210 \times 10^{-3} = 1,47(\text{хв.})$$

2. Mill groove 18 semi-clean

$$To = 4 \times \mathrm{L} = 4 \times 210 \times 10^{-3} = 0,84(\text{хв.})$$

3. Mill the groove 18 finely

$$To = 4 \times \mathrm{L} = 4 \times 210 \times 10^{-3} = 0,84(\text{хв.})$$

$$To = 3,15(\text{хв.})$$

$$T\text{шт.к.} = 3,15 \times 1,51 = 4,75(\text{хв.})$$

055 Diamond boring operation

1. Grind the surface 11 thinly

$$To = 0,3 \times \mathrm{d} \times \mathrm{L} = 0.3 \times 35 \times 25 \times 10^{-3} = 0,2625(\text{хв.})$$

2. Grind the surface 17 thinly

$$To = 0,3 \times \mathrm{d} \times \mathrm{L} = 0.3 \times 50 \times 30 \times 10^{-3} = 0,45(\text{хв.})$$

$$To = 0,7125(\text{хв.})$$

$$Тшт.к. = 0,7125 \times 1,41 = 1,004\left(хв.\right)$$

Average artificial time for all operations:

$$Тшт.сер. = 1,56\left(хв.\right)$$

Determine the estimated amount of equipment required to perform each operation:

$$m = \frac{N \times Тшт.к.}{60 \times Fg \times \eta з.н.}, \qquad (2.7)$$

where N – annual release program, pcs..;

$Тшт.к.$ – artificial calculation time;

Fg – valid annual fund of equipment operation (Fg = 4059 h.)

$\eta з.н.$ - regulatory load factor of equipment (η з.н. = 0,8)

005 Milling operation

$$m = \frac{35000 \times 3.49}{60 \times 4059 \times 0.8} = 0.628 \approx 1$$

Actual equipment load factor

$$\eta з.ф. = \frac{m}{P} = \frac{0,628}{1} = 0,628$$

The number of operations performed on this equipment:

$$О = \frac{\eta з.н.}{\eta з.ф.} = \frac{0,8}{0,628} = 1,27$$

010 Milling operation

$$m = \frac{35000 \times 0423}{60 \times 4059 \times 0,8} = 0,076 \approx 1$$

Actual equipment load factor:

$$\eta з.ф. = \frac{m}{P} = \frac{0,076}{1} = 0,076$$

The number of operations performed on this equipment:

$$О = \frac{\eta з.н.}{\eta з.ф.} = \frac{0,8}{0,076} = 10,53$$

015 Milling operation

$$m = \frac{35000 \times 1,744}{60 \times 4059 \times 0,8} = 0,3133 \approx 1$$

Actual equipment load factor:

$$\eta з.ф. = \frac{m}{P} = \frac{0,3133}{1} = 0,3133$$

The number of operations performed on this equipment:

$$O = \frac{\eta з.н.}{\eta з.ф.} = \frac{0,8}{0,3133} = 2,55$$

020 Milling operation

$$m = \frac{35000 \times 1,11}{60 \times 4059 \times 0,8} = 0,1994 \approx 1$$

Actual equipment load factor:

$$\eta з.ф. = \frac{m}{P} = \frac{0,1994}{1} = 0,1994$$

The number of operations performed on this equipment:

$$O = \frac{\eta зн.}{\eta з.ф.} = \frac{0,8}{0,1994} = 4,012$$

025 Boring operation

$$m = \frac{35000 \times 1,31}{60 \times 4059 \times 0,8} = 0,2354 \approx 1$$

Actual equipment load factor:

$$\eta з.ф. = \frac{m}{P} = \frac{0,2354}{1} = 0,2354$$

The number of operations performed on this equipment:

$$O = \frac{\eta з.н.}{\eta з.ф.} = \frac{0,8}{0,2354} = 3,398$$

030 Boring operation

$$m = \frac{35000 \times 1,29}{60 \times 4059 \times 0,8} = 0,23 \approx 1$$

Actual equipment load factor:

$$\eta з.ф. = \frac{m}{P} = \frac{0,23}{1} = 0,23$$

The number of operations performed on this equipment:

$$O = \frac{\eta з.н.}{\eta з.ф.} = \frac{0,8}{0,23} = 3,49$$

035 Aggregate operation

$$m = \frac{35000 \times 0{,}1625}{60 \times 4059 \times 0{,}8} = 0{,}029 \approx 1$$

Actual equipment load factor:

$$\eta з.ф. = \frac{m}{P} = \frac{0{,}029}{1} = 0{,}029$$

The number of operations performed on this equipment:

$$\text{O} = \frac{\eta з.н.}{\eta з.ф.} = \frac{0{,}8}{0{,}029} = 27{,}6$$

040 Aggregate operation

$$m = \frac{35000 \times 0{,}2596}{60 \times 4059 \times 0{,}8} = 0{,}47 \approx 1$$

Actual equipment load factor:

$$\eta з.ф. = \frac{m}{P} = \frac{0{,}047}{1} = 0{,}047$$

The number of operations performed on this equipment:

$$\text{O} = \frac{\eta з.н.}{\eta з.ф.} = \frac{0{,}8}{0{,}047} = 17{,}02$$

045 Aggregate operation

$$m = \frac{35000 \times 0{,}047}{60 \times 4059 \times 0{,}8} = 0{,}0085 \approx 1$$

Actual equipment load factor:

$$\eta з.ф. = \frac{m}{P} = \frac{0{,}0085}{1} = 0{,}0085$$

The number of operations performed on this equipment:

$$\text{O} = \frac{\eta з.н.}{\eta з.ф.} = \frac{0{,}8}{0{,}0085} = 94{,}11$$

050 Milling operation

$$m = \frac{35000 \times 4{,}75}{60 \times 4059 \times 0{,}8} = 0{,}853 \approx 1$$

Actual equipment load factor:

$$\eta з.ф. = \frac{m}{P} = \frac{0{,}853}{1} = 0{,}853$$

The number of operations performed on this equipment:

$$O = \frac{\eta з.н.}{\eta з.ф.} = \frac{0,8}{0,853} = 0,94$$

055 Diamond boring operation

$$m = \frac{35000 \times 1,004}{60 \times 4059 \times 0,8} = 0,18 \approx 1$$

Actual equipment load factor:

$$\eta з.ф. = \frac{m}{P} = \frac{0,18}{1} = 0,18$$

The number of operations performed on this equipment:

$$O = \frac{\eta з.н.}{\eta з.ф.} = \frac{0,8}{0,18} = 4,44$$

Table 2.1 - Calculation of artificial time for operations

Operation	Тшт.к.	m	P		O
005	3,49	0,628	1	0,628	1,27
010	0,423	0,076	1	0,076	10,53
015	1,744	0,3133	1	0,3133	2,55
020	1,11	0,1994	1	0,1994	4,012
025	2,57	0,2354	1	0,2354	3,398
030	2,57	0,23	1	0,23	3,49
035	0,1625	0,029	1	0,029	27,6
040	0,2596	0,047	1	0,047	17,02
045	0,047	0,0085	1	0,0085	94,11
050	4,75	0,853	1	0,853	0,94
055	1,004	0,18	1	0,18	4,44
Разом	18,13	2,79	11	2,79	169,36

Calculate the value of the coefficient of consolidation of the operation:

$$Kз.о. = \frac{\Sigma O}{\Sigma P} =$$

$$\frac{(1,27 + 10,53 + 2,55 + 4,012 + 3,398 + 3,49 + 27,6 + 17,02 + 0,94 + 4,44)}{(1+1+1+1+1+1+1+1+1+1)} = \frac{75,25}{10} = 7,525$$

Since $К_{з.о}$. is within $1 \le 7{,}525 \le 10$ then we accept large-scale production.

Determine the daily output of products:

$$\mathrm{N}c = \frac{\mathrm{N}}{254} = \frac{35000}{254} = 137{,}8$$

Daily productivity of the current line:

$$\mathrm{Q}c = \frac{Fc \times \eta з.ф.сер.}{Тшт.сер.} \qquad (3.7)$$

Where Fc – daily fund of equipment operation (Fc = 952 min)

$$\eta з.ф.сер. = \frac{\Sigma \eta з.ф.}{n} = \frac{2{,}78}{11} = 0{,}253$$

$$\mathrm{Q}c = \frac{952 \times 0{,}253}{1{,}65} = 145{,}97$$

Daily Nc >Qc×0.6 (137,8>87,58) then we accept the flow form of production, for which we calculate the rate of release:

$$tв = \frac{60 \times Fg}{N} = \frac{60 \times 4029}{35000} = 6.9\ (\mathrm{min})$$

Therefore, we accept a large-scale serial type of production with the current form of its organization.

2.2 The choice and feasibility study of the method of obtaining the workpiece

Let's compare two methods of preparation of preparation - sandy-clay forms and in molding.

Steel is used to make the part СТ45Л. In addition, the part has certain roundings, protrusions, etc. Based on this, it is most advantageous to use casting.

Calculate the cost of two methods of obtaining billets by casting: casting in sand-clay molds and casting in the mold.

The cost of the workpiece obtained by casting into the chill mold is determined by the formula:

$$\mathrm{S}заг. = ((Ci/1000) \times \mathrm{Q} \times \mathrm{k}т \times \mathrm{k}с \times \mathrm{k}в \times \mathrm{k}м \times \mathrm{k}п) - (\mathrm{Q} - \mathrm{q}) \times \mathrm{S}відх./1000,$$

where Ci – base cost of 1 ton of blanks (Ci = 60 00 UAH.), *Q* – workpiece weight, kg;

q – weight of details, kg;

Sвідх. – price for 1 ton of waste (*Sвідх.* = 4 000 UAH.);

km, kc, kв ,kм ,kn – коеф., depending on the accuracy class, complexity group, weight, material brand and production volume [2];

km = 1,1;

kc = 1,22

kв = 1;

kм = 0,93;

kn = 1.

Determine the mass of the part:

$$q = V \times p,$$

where *V*- volume of detail;

p – density of material (for steel 45Л p = 7,8×10^{-o} g/cm^3);

$$V = 551250 + 31500 + 80400 - 26926 - 11618 - 35325 - 43200 - 3240 -$$

$$- 6720 - 6700 \ = \ 479421 \ мм^3;$$

Consider the method of casting in sand-clay molds:

$$Q = q \times 1{,}15 = 3{,}74 \times 1{,}15 = 4{,}3 \text{ (kg)}$$

$$S\text{заг}1 = \left(\frac{60000}{1000} \cdot 4{,}3 \cdot 1{,}1 \cdot 1{,}22 \cdot 1 \cdot 0{,}93 \cdot 1\right) - (4{,}3 - 3{,}74) \cdot \frac{4000}{1000} = 319.76$$

Calculate the method of casting in the mold:

$$Q = q \times 1{,}1 = 3{,}74 \times 1{,}1 = 4{,}114 (кг)$$

$$S\text{заг}2 = \left(\frac{60000}{1000} \cdot 4{,}114 \cdot 1{,}1 \cdot 1{,}22 \cdot 1 \cdot 0{,}93 \cdot 1\right) - (4{,}3 - 3{,}74) \cdot \frac{4000}{1000} = 305.83$$

Economic effect for comparing methods of obtaining blanks:Sзаг1

$$\text{E} = (S\text{заг}1 - S\text{заг}2) \cdot N = (319{,}76 - 305{,}83) \cdot 35000 = 487515 \ UAN$$

We see that there is an economic effect of using the method of casting in the mold. Therefore, it is advisable to choose this method of casting for this process.

2.3 Choice of technological bases

In the first operation, the surfaces are treated, which are then used as base.

After the first operation, the base is carried out on the treated surface. All surfaces to be treated are shown in a thicker line.

005 Milling

$W_{Ao.п.} = W_{Aт.р.} = W_{Aн.р.} + W_{Aт.с.} + W_{Aуст.}$ $W_{Ac.} = W_{Aн.р} + W_{Aт.с.}$

$W_{Ac.} = 0{,}12\ мм$

$W_{Aуст.} = 0{,}04\ мм$

$W_{Ao.п} = 0{,}12 + 0{,}04 = 0{,}16\ мм$

$T\ Ao.п. = 0{,}160$ (h10) $70_{-0.160}$

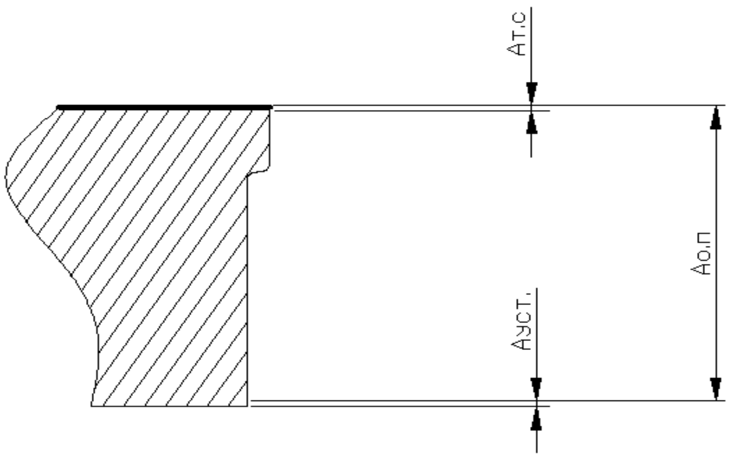

Figure 2.1 - Operation 005 Milling

$W_{Ao.п.} = W_{Aт.р.} = W_{Aн.р.} + W_{Aт.с.} + W_{Aуст.}$

$W_{Ac.} = W_{Aн.р} + W_{Aт.с.}$

$W_{Ac.} = 0{,}15\ мм$ $W_{Aуст.} = 0{,}05\ мм$

$W_{Ao.п} = 0{,}15 + 0{,}05 = 0{,}210\ мм$ $T\ Ao.п. = 0{,}210$ (h12) $20_{-0.210}$

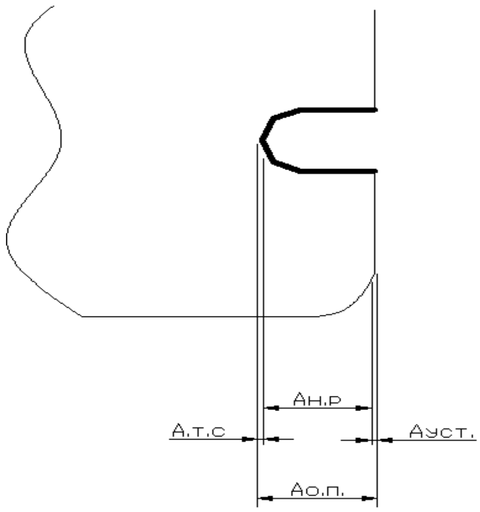

Figure 2.2 - Operation 010 Milling

$W_{Ao.п.} = W_{Aт.р.} = W_{Aн.р.} + W_{Aт.с.} + W_{Aуст.}$

$W_{Aс.} = W_{Aн.р} + W_{Aт.с.}$

$W_{Aс.} = 0{,}15\ мм$

$W_{Aуст.} = 0{,}05\ мм$

$W_{Ao.п} = 0{,}15 + 0{,}05 = 0{,}210\ мм$

$T\ Ao.п. = 0{,}210$ (h12)

$20_{-0.210}$

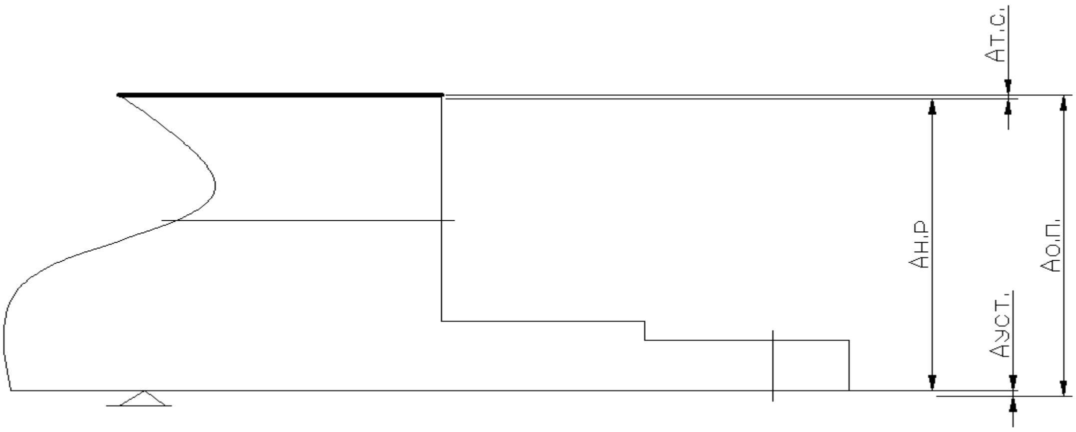

Figure 2.3 - Operation 010 Milling

$Smax = W_A + W_B + Smin$

$W_A = 15мкм$ – *допуск на отвір*

$W_B = 15\ мкм$

$Smin = 13$ *мкм – мінімальний зазор між отворами*

$tga = (0,015 + 0,015 + 0,013) / 184 = 0,00023$

$\varepsilon б = L \times tga = 25 \times 0.00023 = 5.8 мкм$

$\varepsilon з = 35 мкм$

$\varepsilon у = 35,5 мкм$

$T_{Ao.п.} = 0,039 мм (H8)$

$Ø35_{+0.039}$

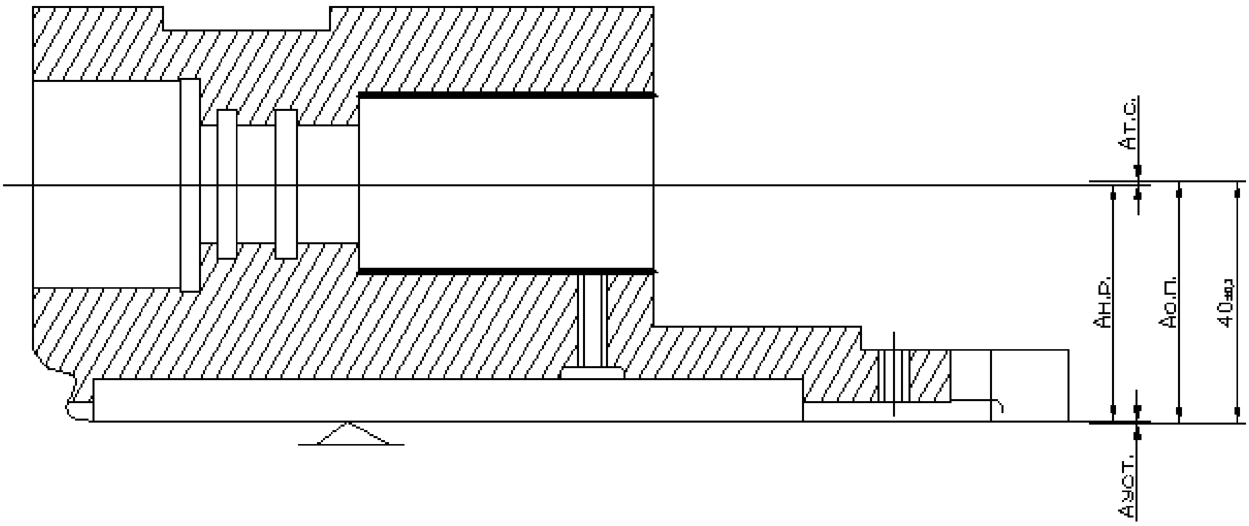

Figure 2.4 - Operation 025 Boring

$W_{Ao.п.} = W_{Aт.р.} = W_{Aн.р.} + W_{Aт.с.} + W_{Aуст.}$

$W_{Ac.} = W_{Aн.р} + W_{Aт.с.}$

$W_{Ac.} = 0,10 мм$

$W_{Aуст.}$ $0,06 мм$

$W_{Ao.п.} = 0,10 + 0,06 = 0,16 мм$

$T_{Ao.п.} = 0,16 (H12)$ $17_{-0.160}$

$W_{Bo.п.} = W_{Bт.р} = W_{Bн.р} + W_{Bт.с} + W_{Bт.с} = 1,2 \ldots 1,5 W_{Bc.}$

$W_{Bc.} = W_{Bн.р} + W_{Bт.с} = 0,15 мм$

$W_{Bo.п.} = 1,2 \times 0,15 = 0,18 мм$

$T\ W_{Bo.п.} = 0,180 мм (H12)$

$150_{-0.18}$

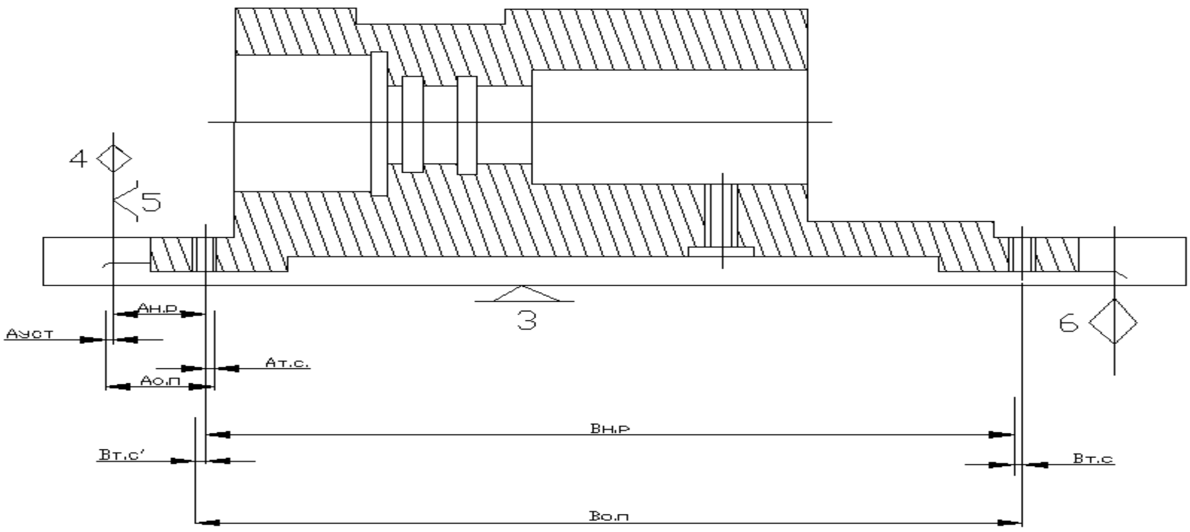

Figure 2.5 - Operation 025 Aggregate

$W_{Ao.n.} = W_{Am.p.} = W_{Ан.р.} + W_{Am.c.} + W_{Aуст.}$ $\qquad W_{Ac.} = W_{Ан.р} + W_{Am.c.}$

$W_{Ac.} = 0,04\ мм$

$W_{Aуст.} = 0,0\ мм,$ Because the treated surface is used

$W_{Ao.n} = 0,04 + 0 = 0,04\ мм \quad T_{Ao.n.} = 0,046(\text{h7}) \qquad 67_{-0.046}$

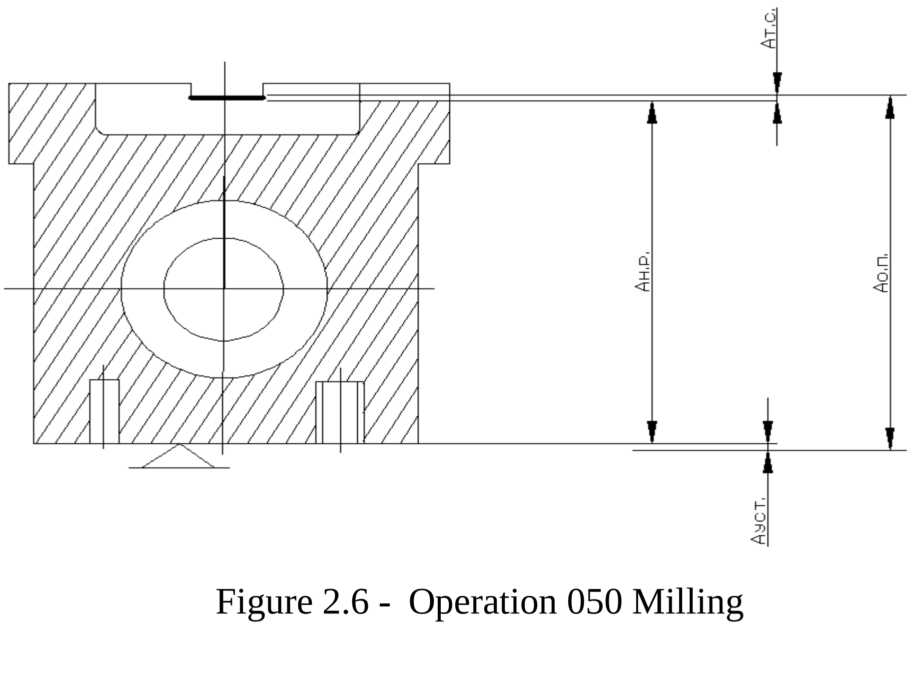

Figure 2.6 - Operation 050 Milling

2.4 Choice of a variant of a technological route of machining

We choose the technological route of processing a part made by an advanced technological process.

005 Milling operation

1. Mill the surface 1 roughly
2. Mill surface 1 semi-clean

010 Milling operation

1. Mill the surface 2 roughly
2. Mill the surface 3 roughly

015 Milling operation

1. Mill the surface 9 roughly
2. Mill the surface 6 roughly
3. Mill groove 7 roughly
4. Mill the surface 4 roughly

020 Milling operation

1. Mill surface 6 semi-clean
2. Mill groove 7 semi-clean
3. Mill surface 4 semi-clean

025 Boring operation

1. Grind the surface 11 roughly
2. Grind the surface 12 roughly
3. Grind the groove 13 roughly
4. Boring grooves 16 at the same time roughly
5. Grind the surface 17 roughly

030 Boring operation

1. Expand the surface 11 cleanly
2. Expand the surface 12 cleanly
3. Grind grooves 16 clean at the same time
4. Expand surface 17 cleanly

035 Drilling operation

1. Drill 2 holes with a diameter of 5 through
2. Drill 2 holes with a diameter of 10 mm and a length of 12 mm
3. Counter 2 holes with a diameter of 5 through
4. Counter 2 holes with a diameter of 10 and a length of 12 mm

040 Drilling operation

1. Drill 4 holes with a diameter of 8 and a length of 12 mm
2. Drill 2 holes 5 with a diameter of 12 mm
3. Counter 4 holes with a diameter of 8 and a length of 12 mm
4. Drill 2 holes 5 with a diameter of 12 mm
5. Expand 2 holes with a diameter of 12 mm and a length of 12 mm

045 Drilling operation

1. Drill a hole with a diameter of 6 through
2. Drill a hole with a diameter of 12 and a length of 3 mm
3. Countersink the hole with a diameter of 6 through
4. Countersink a hole 12 with a diameter of 3 mm

050 Threading operation

1. Cut 2 holes M5-7H through
2. Cut 2 holes M10-7H 12 mm long
3. Cut a thread of 4 holes M8 -7H 12 mm long

055 Threading operation

1. Cut the M6 -7H thread through

060 Milling operation

1. Mill groove 18 roughly
2. Mill groove 18 semi-clean

065 Milling operation

1. Mill the groove 18 finely

070 Boring operation

1. Expand the surface 11 thinly
2. Expand the surface 17 thinly

For economic analysis and selection of the optimal technological process, we use the method of calculating the minimum cost. To do this, consider several technological routes that will differ in the method of surface treatment or equipment used in the technological process. For the basic TP we will take the one given in the table above. The new version differs from the basic in that the holes 3 × Ø 6 i 4 × Ø 10 we will process not on the aggregate machine, and on two multispindle machines of drilling type 2Г175M.

2.5 Determination of allowances for processing and dimensions of the workpiece

To calculate the allowances, we will use the calculation-analytical method. Since in the process of casting we get two holes 14 and 15, we determine the allowances for these surfaces.

Rz = 200 μm – the height of the irregularities on the surface of the workpiece;

h = 300 μm - height of the defective layer.

The values of these parameters after machining the surface will be equal

- for rough boring: *Rz* = 50 μm; *h* = 50 μm;
- for finishing boring: *Rz* = 10 μm; *h* = 25 μm;
- for fine boring: *Rz* = 5 μm; *h* = 10 μm.

At such processing the parameters set on the drawing are reached.

Determine the spatial deviation of the workpiece for Ø 30 H8:

$$\rho = \sqrt{\rho 1^2 + \rho 2^2},$$

where *ρ1* – specific warping of the casting hole, μm;

ρ2 – total displacement of the casting hole, μm.

$$\rho 1 = \sqrt{(\kappa \times d)^2 + (k \times 1)^2}$$

where *k* = 0,7 μm / mm - specific warping of the casting [4];

d = 30 mm is the diameter of the hole;

1 = 50 mm - the length of the hole.

$$\rho 1 = \sqrt{(0{,}7 \times 30)^2 + (0{,}7 \times 50)^2 = 28}(\text{мкм})$$

ρ2 = 200 (μm)

Thus, the spatial deviation of the workpiece:

$$\rho = \sqrt{28^2 + 200^2} = 201{,}95(\text{мкм})$$

Final spatial deviation:

- after rough boring: *ρ1'*= ρ×0,05 = 201,95×0,05 = 10 μm;
- after finishing boring: *ρ2'* = ρ×0,005 = 201,95×0,005 = 1 μm;
- after fine boring: *ρ3'* = ρ×0,0005 = 201,95×0,05 = 0,1 μm;

Since the last two values are quite small, they will not affect the calculations and are neglected.

The calculation data are entered in the table 2.5

Calculations of allowances and limit sizes on technological transitions on processing of an aperture of the case Ø 30 H8 (surface17)

Table 2.5- Calculation of allowances

Technological transitions of surface treatment	Elements allow				2z μm	Estimated size dp, mm	Tolerance Ta, μm	Final size, mm		The final value of the assumption	
	Rz	h	ρ	ε				D min мм	D max мм	2z min mm	2z max mm
Blank	200	300	201,9		-	28,317	620	27,69	28,32	-	-
Rough boring	50	50	10	55	2×709	29,735	160	29,57	29,735	1,42	1,88
Boring clean	10	25	-		2×110	29,955	62	29,89	29,955	0,22	0,318
Boring thin	5	10	-		2×35	30,025	25	30	30,025	0,06	0,107
										1,70	2,305

On the basis of the data

On the basis of the data recorded in the table, we calculate the minimum values of interoperable allowances:

$$2zmin = 2\times(Rzi-1\ +hi-1+\sqrt{\rho i-1^2+\varepsilon i^2});$$

Minimum allowance for rough boring:

$$2zmin1 = 2\times(200+300+\sqrt{201,95^2+55^2}) = 2\times709\text{мкм}$$

Minimum allowance for pure boring:

$$2z\min2 = 2\times(50+50+\sqrt{10^2+0^2}) = 2\times110\text{мкм}$$

Minimum allowance for fine boring:

$$2zmin3 = 2\times(10+25+\sqrt{0^2+0^2}) = 2\times35\ \text{мкм}$$

We begin to determine the estimated size from the endя:

$$dp4 = 30,025$$

for finishing boring: $dp3 = 30,025 - 2\times0,035 = 29,955\text{мм};$

for rough boring: $\text{dp2} = 29,955 - 2 \times 0,11 = 29,735\,\textit{мм}$

for preparation: $\text{dp1} = 29,735 - 2 \times 0,709 = 28,317\,\textit{мм}$.

The maximum size of the hole is calculated as follows:

dmax – we obtain from the calculated diameter d by rounding to the accuracy of the tolerance of the corresponding transition;

dmin – we obtain from the largest limiting size d by subtracting the tolerance of the corresponding transition.

Thus, for fine boring

$$\text{dmax} = 30,025\,\textit{мм};$$

$$\text{dmin} = 30,0\,\textit{мм}.$$

For pure boring

$$\text{dmax} = 29,955\,\textit{мм};$$

$$\text{dmin} = 29,955 - 0,062 = 29,893\,\textit{мм}.$$

For rough boring $\text{dmax} = 29,735\,\textit{мм}$;

$$\text{dmin} = 29,735 - 0,160 = 29,575\,\textit{мм}.$$

For the workpiece

$$\text{dmax} = 28,317\,\textit{мм};$$

$$\text{dmin} = 28,317 - 0,620 = 27,697\,\textit{мм}.$$

Minimum limit values of allowances $2z_{\min}^{гр}$ equal differences between the largest limits of this transition and the previous, and the maximum value

$2z_{\max}^{гр}$ - according to the difference of the smallest limit sizes.

Then, for fine boring:

$$2z_{\min 3}^{гр} = 30,025 - 29,955 = 0,060 = 2 \times 0,030\,\textit{мм};$$

$$2z_{\max 3}^{гр} = 30 - 29,893 = 0,107 = 2 \times 0,0535\,\textit{мм}.$$

for finishing boring:

$$2z_{\min 2}^{гр} = 29,955 - 29,735 = 0,220 = 2 \times 0,110\,\textit{мм};$$

$$2z_{\max 2}^{гр} = 29,893 - 29,575 = 0,318 = 2 \times 0,159\,\textit{мм}.$$

for rough boring:

$$2z_{\min 1}^{гр} = 29,735 - 28,317 = 1,418 = 2 \times 0,709\ мм;$$

$$2z_{\max 1}^{гр} = 29,575 - 27,697 = 1,878 = 2 \times 0,939\ мм.$$

General allowances $z_{\min}^{заг}$ and $z_{\max}^{заг}$ we obtain by adding intermediate allowances:

$$2z_{\min}^{заг} = 1,418 + 0,220 + 0,060 = 1,698 = 2 \times 0,849\ мкм;$$

$$2z_{\max}^{заг} = 1,878 + 0,318 + 0,107 = 2,303 = 2 \times 1,1515\ мкм.$$

Total nominal allowance

$$2z_{заг}^{ном} = z_{\min}^{заг} + h_{заг} - h_{дет} = 1698 + 300 - 25 = 1973 = 2 \times 986,5мкм$$

$$d_{ном} = d_{дет}^{ном} - z_{заг}^{ном} = 30 - 1,973 = 28,017мм.$$

We check the correctness of the calculations:

$$z_{\max 3}^{гр} - z_{\min 3}^{гр} = 135 - 60 = 75мкм;$$

$T_2 - T_1 = 100 - 25 = 75\ мкм;$

$75\ мкм = 75\ мкм$

$$z_{\max 2}^{гр} - z_{\min 2}^{гр} = 420 - 220 = 200\ мкм;$$

$T_3 - T_2 = 300 - 100 = 200\ мкм$

On other processing surface details allowances and tolerances are chosen according to tables.

Table 2.6 - Allowances and tolerances are selected by tabular method

№ surface	Size, mm	Allowance, mm
1	210H10	2×2,3
2,3	20H12	2×1,3
4	35H10	2×1,3
6,7,8	105H10	2×2,2
9	35H12	2×1,3
11	Ø35H8	2×1,3
12	Ø20H9	2×1,2
17	Ø30H8	2×1,2
18	12h7	2×1,4

2.6 Choice of cutting, measuring and auxiliary tools

During this technological process it is necessary to carry out at least two control operations to determine the geometric accuracy of the holes, their alignment, parallelism.

During one of the control operations we determine compliance with the alignment of the distance of 0.05 mm between the holes and dimensions Ø 30 P8 mm and Ø 35 H8mm

In another operation, you can establish the parallelism of the surface of the hole Ø 35 H8 relative to the base surface B.

At the final stage of processing of a detail it will be expedient to control cutting of a cut for apertures Ø 5 mm, Ø 10 mm, Ø 8 mm.

In addition to these holes, control operations can be set for surfaces with specified rigid processing conditions.

Auxiliary operations can be applied at the beginning of the machining process for casting parts. This also includes transport operations to move workpieces from machine to machine.

Quality control of details is carried out statistically. The statistical method of part size control has the advantage of fatigue, as it allows you to virtually eliminate the lack of parts.

In practice, it is carried out selectively at certain intervals.

Control is carried out at the workplace by the contractor every hour, the number of units in the sample – 5.

The control of the sizes is carried out by the universal tool - a caliper ШЦ I-125-0,1-1 and longitudinal calibers: brackets 8113-0159 f9; cork 8133-0932 H10, 8133-0950 H9; linear calibers 8151-6201 18 $\pm$0,5; 8151-6202 143 $\pm$0,3

2.7 Determination of processing modes and technical time norms

Consider the sequence of calculation of cutting modes on the example of the drilling operation of the hole Ø 10 calculation and analytical method.

Choose a cutting tool - a drill.

Dimensions of the working part:

D = 9 mm, d = 8 mm,

L = 20 mm,l = 18 mm.

Depth of cut: t=4.5 mm, D = 9 mm.

Feed: s = 0,5 mm / rev.

The cutting speed is determined by the formula:

$$v = \frac{Cv \times D \times Kv}{T \times t \times s},$$

where $Cv = 18,0$ – correction factor (table.29 [3]);

$q = 0.6; x = 02; y = 0,3; m = 0,25$ – indicators of degrees;

$T = 20$ – period of stability;

Kv – total correction factor for cutting speed:

$$Kv = Kmv \times Kuv \times Kiv \times Knv;$$

where $Kmv = Kz \times \frac{750}{\sigma b} = 1 \times \frac{750}{800} = 0,94$ - material-dependent coefficient;

$Kuv = 1,0$ - coefficient that takes into account the material of the tool;

$Kiv = 1,0$ – a factor that takes into account the depth of drilling;

$Kuv = 0,8$ – additional correction factor for drilling;

$$Kv = 0,94 \times 1 \times 1 \times 0,8 = 0,752.$$

So:

$$v = \frac{18,0 \times 9 \times 0,752}{20 \times 4,5 \times 0,5} = 28,1 м / хв. \quad (2.8)$$

Determine the spindle speed:

$$n = \frac{1000 \times v}{\pi \times D} = \frac{1000 \times 28,1}{3,14 \times 9} = 895 об / хв;$$

We accept the value of the speed according to the passport data of the machine:

$$n = 800 \; об / хв.$$

Then the cutting speed:

$$v\partial = \frac{\pi \times D \times n\varphi}{1000} = 25,12 м / хв.$$

The torque is determined by the formula:

$$Мкр = 10 \times См \times \mathrm{D} \times \mathrm{t} \times \mathrm{s} \times Кр;$$

where $См = 0,09$ – correction factor;

$\mathrm{K}p = \frac{HB}{190} = \frac{190}{190} = 1$ - a factor that takes into account the actual processing conditions;

$\mathrm{q} = 1; \mathrm{x} = 0.9; \mathrm{y} = 0.8$ – indicators of degrees [3].

Then

$$Мкр = 10 \times 0,09 \times 10 \times 5 \times 0,5 \times 1 = 23,5\ Нм.$$

Axial force is determined by the formula:

$$Po = 10 \times Cp \times \mathrm{t} \times \mathrm{s} \times Кр;$$

where $Cp = 67$ – correction factor;

$x = 1,2;\ y = 0,65$ – indicators of degrees;

$Кр = 1$ – axial force correction factor.

Then

$$Po = 10 \times 67 \times 5 \times 0,5 \times 1 = 2769\ H.$$

The cutting power is determined by the formula:

$$N = \frac{Mk\rho \times n}{9750} = \frac{23,5 \times 800}{9750} = 2,16 кВт.$$

$\mathrm{N}_{факт.}$ machine according to passport data:

$$\mathrm{N}_{факт} = 4,2\ кВт.$$

Since, 4,2>0.6, then the cutting modes are selected correctly. We accept the vertical drilling machine 2P125.

Consider the rationing of the technological process on the example of operation 025 - boring.

$$Тшт. = То + Тд + Тоб + Твідп, \quad (2.9)$$

where $То$ – main time, min;

$Тд$ – auxiliary time, min;

$Тоб$ – time for workplace maintenance, min.;

Similarly, we determine the cutting mode for other operations and transitions.

Table 2.7 - Calculation of cutting modes

№ operation	Name op., Type of machine	№ transition.	Depth of cut	Feed		Cutting speed v, m / min	Speed n, rpm.	Max cutting power N, kW
				So mm / rev	Sz mm / rev			
005	Milling	1	0,9	-	0,15	47,5	500	1,9
		2	0,2	-	0,15	10,64	315	
010	Milling	1	0,9	-	0,15	55,2	530	2,2
		2	0,9	-	0,15	55,2	530	
015	Milling	1	0,9	-	0,15	23,75	150	0,94
		2	0,2	-	0,15	5,28	100	
020	Milling	1	0,9	-	0,15	14,93	355	1,9
		2	0,2	-	0,15	3,32	250	
025	Boring	1	0,5	0,6	-	75,4	800	0,94
		2	0,5	0,6	-	50,3	630	
		3	0,9	0,3	-	68,9	710	
		4	2,2	0,3	-	43,8	560	
		5	0,5	0,6	-	87,9	930	
030	Boring	1	0,3	0,3	-	22,8	800	0,5
		2	0,3	0,3	-	15,3	710	
		3	0,3	0,18	-	10,7	630	
		4	0,3	0,3	-	25,6	930	
035	Aggregate	1	4,8	0,5	-	25,12	425	3,25
		2	0,2	0,7	-	23,5	375	
		3	2,2	0,5	-	15,6	250	
		4	0,2	0,7	-	12,8	230	
040	Aggregate	1	3,8	0,5	-	25,12	425	3,84
		2	0,2	0,7	-	17,6	250	
		3	2,2	0,5	-	22,6	425	
		4	0,2	0,7	-	14,2	375	
		5	0,1	2,2	-	51,2	500	
045	Aggregate	1	2,8	0,5	-	34,5	800	2,16
		2	0,2	0,5	-	22,5	425	
		3	5,8	0,7	-	25,12	500	
		4	0,2	0,7	-	18,4	375	

Continuation of Table 2.7

050	Milling	1 2 3	0,9 0,2 0,1	- - -	0,15 0,15 0,15	47,5 18,6 12,8	500 355 315	1,9
055	Milling	1 2	0,1 0,1	0,2 0,2	- -	24,3 22,1	710 630	0,4

Consider the rationing of the technological process on the example of operation 025 - boring.

Твідп – time of breaks for rest and personal needs, min.

Consider the definition *To*.

$$\text{T}o = \frac{L}{Sz \times n}, \tag{2.10}$$

where $\text{L} = \text{L}_1 + \text{L}_2 + \text{L}_3$ – processing length;

L_1 - the size of the incision, mm;

L_2 – additional length for removal of test shavings, mm;

L_3 – the magnitude of the flow, mm;

Sz - tooth feed, mm / tooth;

n – tool speed, min $^{-1}$.

$$Тоб = Торг = Ттехн, \tag{2.11}$$

where *Торг* – time for organizational maintenance, min.;

Ттехн – time for maintenance, min.

$$Тд = Ту.с + Тз.о + Туп. + Твим., \tag{2.12}$$

where *Ту.с* - time for installation and removal of a detail, min.;

Тз.о – time for fastening and unfastening of a detail, min.;

Туп. – time for management techniques, min.;

Твим. – time to measure the part, min.

$\text{k} = 1.5$ – correction factor for large-scale production.

Operation 025 consists of 5 transitions. We choose the main time from the previous point.

Let's choose the auxiliary time of the technological process [2].

$Ty.c1 = 0,08;$

$Ty.c2 = 0,08;$ (since the part is processed by one institution, then Ty.c = 0,08);

$$Tycm. = Ty.c + Tз.o \quad (2.13)$$

$$Туп = 0,01 + 3 \times 0,01 = 0,04\ хв.$$

$$Твим. = 0,09\ хв.$$

$$Тд = 0,08 + 0,04 + 0,09 = 0,21 \times 1,5 = 0,315\ хв.$$

Table 2.8 - Standardization of the technological process

№ oper.	The name of the operation	*Number of transitions.*	*To*	*Sz*	*L*	*Ton*
005	Milling	1 2	0,15 0,15	500 500	20+210+20=250 20+210+20=250	3,33 3,33
010	Milling	1 2	0,15 0,15	500 500	15+20+15=50 15+20+15=50	0,67 0,67
015	Milling	1 2	0,15 0,15	500 500	15+65+15=95 15+65+15=95	1,2, 1,27
020	Milling	1 2	0,15 0,15	500 500	15+65+15=95 15+65+15=95	1,2, 1,27
025	Boring	1 2 3 4 5	0,6 0,6 0,3 0,3 0,6	800 800 800 800 800	5+25+5=35 5+30+5=40 2+3+2=7 2×(2+3,7+2)=15,4 5+50+5=60	0,073 0,084 0,029 0,064 0,125
030	Boring	1 2 3 4	0,3 0,3 0,18 0,3	800 800 800 800	5+25+5=35 5+30+5=4 2×(2+3,7+2)=15,4 5+50+5=60	0,146 0,168 0,11 0,25

Continuation of Table 2.8

035	Aggregate	1	0,5	800	2×(2+12+2)=32	0,08
		2	0,7	800	2×(2+9+2)=26	0,05
		3	0,5	800	2×(2+12+2)=32	0,08
		4	0,7	800	2×(2+9+2)=26	0,05
		5	1	315	2×(2+12+2)=32	0,11
		6	1	315	2×(2+9+2)=26	0,09
040	Aggregate	1	0,5	800	4×(2+12+2)=64	0,16
		2	0,7	800	2×(2+12+2)=32	0,06
		3	0,5	800	4×(2+12+2)=64	0,16
		4	0,7	800	2×(2+12+2)=32	0,06
		5	2,2	500	2×(2+12+2)=32	0,03
		6	1	315	4×(2+12+2)=64	0,21
045	Aggregate	1	0,5	800	2+15+2=1,	0,05
		2	0,7	800	2+3+2=7	0,013
		3	0,5	800	2+12+2=16	0,05
		4	0,7	800	2+3+2=7	0,013
		5	1	315	2+12+2=16	0,06
050	Milling	1	0,15	500	20+210+20=250	3,33
		2	0,15	500	20+210+20=250	3,33
		3	0,15	500	20+210+20=250	3,33
055	Boring	1	0,2	800	5+25+5=35	0,22
		2	0,2	800	5+50+5=60	0,38

Determine the operational processing time:

$$Ton. = To + T\partial \qquad (2.14)$$

The operating time will be determined for each machining of surfaces during the operation 025.

Rough boring of a surface 11: $Ton.1 = 0.185 + 0,315 = 0,473$ *хв.*;

Rough boring of a surface 12: $Ton.2 = 0.185 + 0,315 = 0,473\ xв.$;

Time for rest and maintenance of equipment is determined by the formula:

$$Tоп.відп. = \frac{топ. \times Поп.відп.}{100},$$

where $Поп.відп.$ – costs of rest and service in % of operational time [2].

$Поп.відп.$ = 6%;

So the artificial time for this operation:

$$Тшт = 2,49 + 2,38 + 0,3 + 0,34 = 5,51\ хв.$$

Similarly, we calculate Tsh for other operations.

Table 2.9 - Results of artificial time calculation $T_{шт}$

№	The name of the transition	To, min.	Тдоп., min.	Тоб., min.	Твідп., min.	Тшт., min.
005	Milling	6,67	0,8	1,28	0,53	9,28
010	Milling	1,34	0,8	0,1	0,14	2,2
015	Milling	2,54	0,8	0,21	0,24	3,89
020	Milling	2,54	0,8	0,21	0,24	3,89
025	Boring	0,375	1,66	0,13	0,145	2,31
030	Boring	0,674	1,33	0,13	0,141	2,28
035	Aggregate	0,46	3,02	0,029	0,023	3,54
040	Aggregate	0,68	2,48	0,043	0,034	3,24
045	Aggregate	0,19	2,2	0,012	0,01	2,42
050	Milling	9,09	1,2	0,57	0,64	11,5
055	Boring	0,60	0,53	0,04	0,045	1,22

We will clarify the type of production.

Calculate the required number of machines for each operation:

$$np = \frac{Тшт \times N}{F\partial \times 60};$$

$$n005 = \frac{9,28 \times 35000}{4029 \times 60} = 1,34$$

$$n010 = \frac{2,2 \times 35000}{4029 \times 60} = 0,32$$

$$n015 = \frac{3{,}89 \times 35000}{4029 \times 60} = 0{,}57$$

$$n020 = \frac{3{,}89 \times 35000}{4029 \times 60} = 0{,}57$$

$$n025 = \frac{2{,}31 \times 35000}{4029 \times 60} = 0{,}34$$

$$n030 = \frac{2{,}28 \times 35000}{4029 \times 60} = 0{,}33$$

$$n035 = \frac{3{,}54 \times 35000}{4029 \times 60} = 0{,}52$$

$$n040 = \frac{3{,}24 \times 35000}{4029 \times 60} = 0{,}47$$

$$n045 = \frac{2{,}42 \times 35000}{4029 \times 60} = 0{,}35$$

$$n050 = \frac{11{,}5 \times 35000}{4029 \times 60} = 1{,}67$$

$$n055 = \frac{1{,}22 \times 35000}{4029 \times 60} = 0{,}18$$

The values of the calculations are entered in table. 2.10

Table 2.10 - Clarification of the type of production

№ operations	*np*	*P*	*ηз.ф.*	*O*
005	1,34	2	0,67	1,12
010	0,32	1	0,32	2,35
015	0,57	1	0,57	1,32
020	0,57	1	0,57	1,32
025	0,34	1	0,34	2,21
030	0,33	1	0,33	2,27
035	0,52	1	0,52	1,44
040	0,47	1	0,47	1,60
045	0,35	1	0,35	2,14
050	1,67	2	0,84	0,89
055	0,18	1	0,18	4,17

We set the number of jobs for each operation, rounding to the nearest greater number the obtained values of np.

For all operations we find the actual load factor according to the formula:

$$\eta_{з.ф.} = \frac{n_p}{P} \tag{2.15}$$

The number of operations performed at the workplace is determined by the formula:

$$O = \frac{\eta_{з.н.}}{\eta_{з.ф.}}; \tag{2.16}$$

where $\eta_{з.н.}$ – regulatory load factor of equipment.

Determine the coefficient of consolidation of the operation:

$$К_{з.о.} = \frac{1,12+2,35+1,32+1,32+2,21+2,27+1,44+1,60+2,14+0,89+4,17}{2+1+1+1+1+1+1+1+1+2+1} = \frac{20,83}{13} = 1,60$$

Thus, the type of production is large-scale.

3. DESIGN PART

3.1 Choice and substantiation of the principle of operation of the structural system

The device is designed to install and secure parts. The annual production program is 35,000 pieces. The working surface of the machine on which the device is installed has dimensions of 320 × 1250 mm.

The device must ensure a certain accuracy and reliability. When the parts are installed on the device, it is mounted at one end on the outer housing and pressed by the movable housing from the other end by means of a pneumatic cylinder.

Special machine tools are used in large-scale production. They have one purpose to perform certain machining operations of a particular part.

Consider the device used to machine holes in the machine tool. In this case, two types of layout schemes are possible: with horizontal and vertical arrangement of the machining surface. When mounted vertically, you can use pneumatic clamping jaws to secure the part. But the placement of the workpiece in such a processing scheme will have some base errors, which together with the errors of the device will give significant processing errors. In addition, to place the workpiece in the sponges will need to develop support plates of complex shape.

At a horizontal arrangement of a processing surface we use the clamping device with the pneumatic drive. This arrangement of the workpiece does not give a base error, and this device can be used on other machines. Due to the above, we use a pneumatic heater.

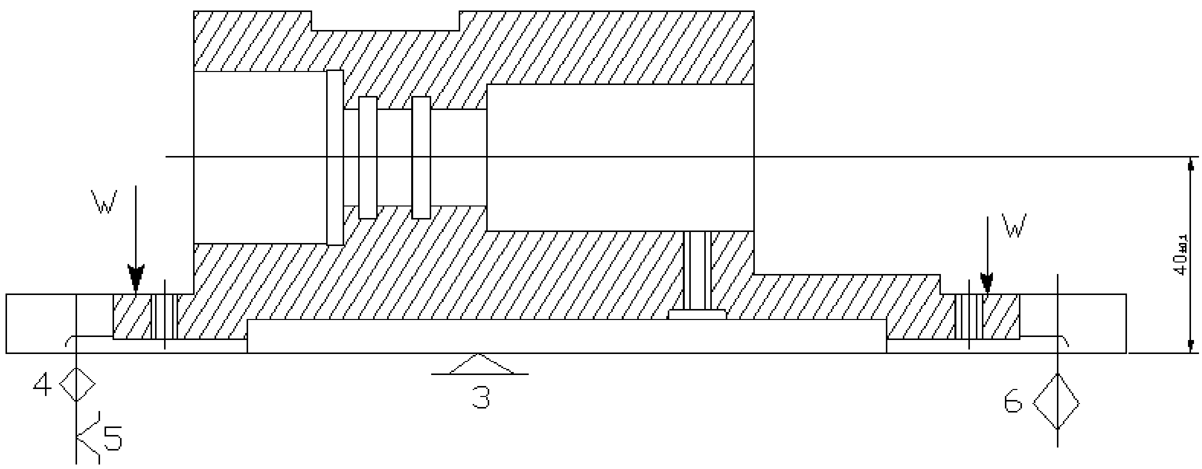

Figure 3.1 - Layout diagram

In this TP we will consider the device for boring of a surface. The position of the part is fixed due to the clamping force R. The number of supports must be the minimum necessary. The supports are used to orient the workpiece in space, they absorb the clamping forces of the workpiece and the cutting force during processing. The design and dimensions of the installation parts of the devices in most cases are selected from the standards.

As support elements we choose support plates which have rather high wear resistance. They are made of CT15 with subsequent cementing and guaranteeing hardness HRC 50-55.

For our TP as the clamping mechanism we use the pneumatic drive which structure includes the engine and a rod. The advantages of this mechanism include: high speed, simplicity of design, independence of the pneumatic actuator from fluctuations in ambient temperature.

3.2 Power calculation of drive parameters

In this case, the workpiece is mounted on plates on the lower base surface and fixed with a healing mechanism.

At the same time there is a circular force Po and horizontal force Pн.

Clamping force:

$$\mathrm{F} = \mathrm{f} \times \mathrm{W}; \partial e \mathrm{f} = (0,1 \ \ldots \ 0,25)$$ – coefficient of friction.

Clamp force:

$$W = \frac{K \times \sqrt{Po^2 + Pн^2}}{f}; \text{м} \quad (3.1)$$

where K – stock ratio.

$$W = \frac{K \times Mкк}{fзз \times \frac{D}{2} + foo \times \frac{D}{2\sin\alpha}}; \quad (3.2)$$

where K – the coefficient of fixing the workpiece;

M – torque;

f зм = 0,16 – coefficient of friction at the point of contact of the workpiece with the clamping device;

fоп = 0,16 – coefficient of friction of the workpiece with support;

D – hole diameter;

d – prism angle; α = 90°.

Torque:

$$Мкр = 10 \times См \times D^{q} \times Sy \times Kp; \tag{3.3}$$

Values of coefficients:

См=0,345

Q=0,2;

y=0,8;

Kp=0,8.

$$Мкр = 10 \times 0,0345 \times 220^{0,2} \times 0,22^{0,2} \times 0,8 = 47\left(Н \times мм\right).$$

Then the clamping force:

$$W = \frac{2,59 \times 47}{0,16 \times \frac{30}{2} + 0,16 \times \frac{30}{2\sin\frac{90^{o}}{2}}} = 139,4\left(Н\right)$$

$$К = Ко \times К_1 \times К_2 \times К_3 \times К_4 \times К_5 \times К_6,$$

where $К_0$ = 1,5 – guaranteed stock ratio;

$К_1$ = 1 – takes into account changes in cutting forces;

$К_2$ = 1 - takes into account the change in cutting forces when blunting the tool;

$К_3$ = 1,15 - takes into account the change in cutting forces during continuous cutting;

$К_4$ = 1 – characterizes the stability of the clamping forces;

$К_5$=1 – the coefficient of profitability of the device controls;

$К_6$ = 1,5

$$К = 1,5 \times 1 \times 1,15 \times 1 \times 1 \times 1 \times 1,15 = 2,59$$

Since W = Рц (clamping force of the pneumatic cylinder), then

$$Рц = \frac{\pi\left(Дц^2 + d^2\right)}{4} \times W; \tag{3.4}$$

$$Dц = \sqrt{\frac{4Pц}{\pi P} + d^2};$$

$$Dц = \sqrt{\frac{4 \times 139,4}{3,14 \times 0,4} + 25^2} = 121 (мм)$$

where d – rod diameter; we accept d = 25mm;

P – air pressure; P = 0,4 MPa;

We accept *Dц* = 125 mm;

Machine drive efficiency η = 0,8 from the passport data of the machine.

3.3 Calculation of accuracy

To ensure the required accuracy of the workpiece, the conditions must be met:

$$\varepsilon\Sigma < T$$

That is the total error εΣ processing should be 10 - 15% less than the tolerance maintained most accurately in this operation.

The total error is equal:

$$\varepsilon\Sigma = K\sqrt{\varepsilon_C^2 + \varepsilon_{Р.Н}^2 + \varepsilon_{Р.У}^2 + \varepsilon_б^2 + \varepsilon_З^2 + \varepsilon_{РН.е}^2 + \varepsilon_И^2 + \varepsilon_{Р.И}^2 + \varepsilon_{1.3}^2 + \varepsilon_Т^2 + \varepsilon_{П.Д.}^2} \quad (3.5)$$

where ε_C - error of the milling machine in an unloaded condition;

$\varepsilon_{р.н.}$ – error in the location of the device on the machine;

$\varepsilon_{р.у.}$ – the error of the location of the mounting elements relative to the surface.

By carefully calibrating the device on the machine, these errors are reduced to zero.

εб = 30 μm - base error;

εз = 48 μm - fastening error;

εр.н. = 45 μm - error in the location of the guide elements;

ε1 = 0 – tool error;

εр.і. = 42 μm - the error of the location of the tool on the machine;

εз.н. – the error is caused by wear of the cutting tool, εз = 17;

εн = 8 μm - the error of the location of the tool relative to the guide elements;

εп.д. = 0 – the error is caused by elastic deformations;

The final formula will look like:

$$\varepsilon\Sigma = 1{,}1\sqrt{\varepsilon_{б}{}^{2} + \varepsilon_{р.н.}{}^{2} + \varepsilon_{з}{}^{2} + \varepsilon_{рн.е}{}^{2} + \varepsilon_{И}{}^{2} + \varepsilon_{з.н.}{}^{2}} = 1{,}1\sqrt{30^{2} + 45^{2} + 48^{2} + 8^{2} + 17^{2}} = 85$$

Taking into account that T = 100 μm, we can conclude that the required accuracy of processing on the device is maintained:

$$\varepsilon\Sigma < T \text{ на } 15\%.$$

3.4 General description of the structure, principle of operation, economic justification

This device is intended for boring of an aperture of a detail - the case. Its design is designed specifically for this operation.

The part is mounted on a plate 3, which is attached to the rack of the housing 2. By means of a cylindrical finger 4, the clamp 5 fixes the position of the working part. Pneumatic cylinder 1 is attached to the device body. A clamp is attached to the rod 9 of the pneumatic cylinder 5.

The machine tool is attached to the machine table with bolts that are wound into the T-shaped grooves of the table and the earbuds of the device.

In the initial position, air is not supplied to the rodless cavity of the pneumatic cylinder. The rod is taken to the extreme position and the clamp is taken away from the part. When air enters the rodless cavity, the rod moves, thereby using a clamp to fix the position of the workpiece.

Next is the processing process after which the air is released from the rodless cavity and the rod is removed to the extreme position.

To verify the correctness of the designed device and the rationality of its use, we calculate the cost of the device:

$$C_{пр} = C_{у.д.} \times Д_{пр} \times K_{скл}, \quad (3.6)$$

where $C_{у.д.}$ - ≤ 4 UAH. - the cost of one condition of adaptation;

$Д_{пр}$ – the number of parts of the device;

Annual costs of using the device:

$$C_{пр.р.} = C_{пр}\left(\frac{1}{A} + \frac{q}{100}\right), \quad (3.7)$$

where A = 1 – depreciation period, hours;

q – the annual costs associated with the operation of the device, we assume q = 20% of the cost $C_{сп.р}$

$$C_{пр.р.} 20(1+0,2) = 24 \ (грн.)$$

We see that the cost of using this device is small, so its use is cost-effective.

4. LIFE SAFETY AND FUNDAMENTALS OF LABOR PROTECTION

4.1 Characteristics of the project site in terms of labor protection

Occupational safety is a system of rules and measures that ensure safe work in this industry. When working on a metal-cutting machine, it is necessary to provide a number of requirements that would allow the employee to perform the task assigned to him in the conditions provided by the design documents.

- Metal-cutting equipment of the following groups is installed at the site:
- lathe;
- drilling;
- milling;
- aggregate.

The installed equipment is designed to perform work that is related to the removal of chips, ie it is necessary to carry out its proper operation in order to prevent injuries to workers. The equipment is placed in the course of the technological process. Transfer from the machine to the machine of details is made by means of the crane beam or the crane.

For the manufacture of the part selected for diploma design, carbon steel is used. 45. A detailed analysis of its physical and mechanical properties, as well as chemical composition shows that during its processing there will be hazardous and harmful factors characteristic of machining: increased voltage in the electrical circuits of metal-cutting machines; general vibration that occurs during the operation of metal-cutting equipment; noise from the operation of machines; excess of obvious and complete heat; dust pollution and others.

In order to prevent the negative impact of the identified dangerous and harmful production factors on the health of workers, to prevent occupational injuries during the technological process of manufacturing parts, we provide the following general measures: rational organization of workplaces; regular control of the correctness of all methods of work when performing operations of the technological process; timely planned and preventive repairs of production equipment and tools; maintenance of passages and passages in the proper order; rational modes of execution of all main and auxiliary operations of the technological process; effective use of personal protective equipment, timely control of their condition, compliance with the required (established by the norms) frequency of their replacement; use of modern safety devices and fencing of working areas; carrying out systematic control of the condition of equipment and auxiliary devices and others.

As treatment-and-prophylactic measures, we envisage preliminary and periodic (at least once a year) medical examinations of shop workers, prohibition of admission to vibration work of persons under 18 years of age and those who have appropriate contraindications to health conditions, therapeutic gymnastics and hand massage.

4.2 Providing standardized parameters of workplace lighting

To calculate the artificial lighting of the production room (shop) we use the method of using the coefficient of luminous flux. When calculating this method takes into account the luminous flux reflected from the walls and ceiling.

The calculation is based on the formula

$$F = \frac{E \times S \times z \times k}{n \times \eta}, \tag{4.1}$$

where F – luminous flux of one lamp, λ;

E = light, λ;

S – area, m ^{2};

K – stock ratio;

η – utilization factor of the lighting installation;

n – the required number of lamps.

We choose the location of lamps. For the production room, in which the developed technological process is implemented, the most optimal is the symmetrical placement of lamps, which will provide uniform lighting of the whole shop (Fig. 5.1).

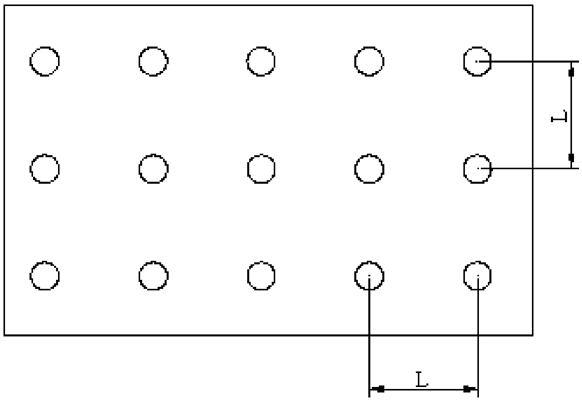

Figure 4.1 - Placement of lamps in the shop

Determine the distance between the lamps L to the height of their suspension N. By (3) with symmetrical placement of the ratio lamps $\frac{L}{H} = 1,2 - 2$.

We will accept $\frac{L}{H} = 1,2$.

The height of the lamps above the lighting surface:

$$H = H_1 - h_c - h_p, \tag{4.2}$$

where H_1 – total height of the room, $H = 8м$;

h_c – distance from the ceiling to the bottom of the lamp, m;

h_p – height from the floor to the lighting surface, m.

That is:

$$H = 8 - 1 - 1 = 6м.$$

Determine the required number of lamps n:

$$n = \frac{S}{L}, \tag{4.3}$$

where S – the area of the lighting room;

L – the distance between the lamps.

Square S:

$$S = a \times b, \tag{4.4}$$

where α– the width of the room and b is the length of the room.

The distance between the luminaires L with the ratio $\frac{L}{H} = 1.2$:

$$L = 1.2\ ,\ H = 1.2 \times 6 = 7.3\ м.$$

Then n:

$$n = \frac{2500}{7.2} = 48.22$$

We accept the number of lamps n = 50 pieces.

To determine the coefficient η determine the index of the room and.

For (4.3) the room index is equal to:

$$i = \frac{a \times b}{H \times (a + b)}, \tag{4.5}$$

That is:

$$i = \frac{25 \times 100}{6 \times (25 + 100)} = 3.33$$

According to the found indicator of the room and the coefficients of reflection of light flux from the walls and ceiling of the room and the surfaces of the equipment, we determine the coefficient of light flux utilization.

When the reflection coefficients of the walls and ceiling p = 0.7 and the indicators of the room and = 3 utilization factor (for (3)), we take equal η=0,59.

The coefficient of non-uniformity z is the ratio of the average illuminance E_{cp} to the minimum illumination E_{min} , that is

$$z = \frac{E_{cp}}{E_{\min}}. \tag{4.6}$$

According to recommendation (3), z has a value from 1.1 to 1.5 and depends on the ratio $\frac{L}{H}$. When $\frac{L}{H} = 1.2$ we accept: z=1.3.

The margin factor k, which takes into account the change in lighting during operation (for (3)), is assumed to be equal to 1.3 (for incandescent lamps).

Having obtained all the initial data, according to the formula (5.1.) Determine the luminous flux of the lamp:

$$F = \frac{300 \times 2500 \times 1.3 \times 1.3}{50 \times 0.59} = 17850.1 \text{ λm.}$$

According to (3) (Table 15), we accept the incandescent lamp of the brand НГ-1000

4.3 Emergency safety

In terms of compliance with the requirements, we envisage the development of comprehensive measures to ensure fire safety; development and approval of regulations and instructions within the enterprise, where the developed technical process will be implemented, the implementation of constant control over their compliance; ensuring compliance with fire safety requirements, standards, norms, rules, as well as compliance with the requirements of regulations and resolutions of the state fire supervision; maintenance of fire protection and communication equipment, firefighting equipment, equipment and inventory, prevention of their misuse; implementation of measures for the introduction of automatic means of detecting and extinguishing fires; timely informing the fire brigade about the malfunction of fire equipment, fire protection systems, water supply, etc.

At the sections of the mechanical shop we envisage the installation of fire shields equipped with carbon dioxide fire extinguishers, diggers, crowbars, buckets, axes. Around the boards we provide for the installation of boxes with sand, the dryness of which is regularly checked. To extinguish possible fires, we also envisage the use of asbestos blankets.

For automatic fire detection, we provide equipment for the production room, where metalworking equipment is installed, sensors with different principles of operation, which promptly notify of a fire and give the command to turn on the automatic fire extinguishing system. The use of sprinkler and drencher installations ensures high fire extinguishing efficiency.

CONCLUSIONS

The engineering decisions accepted in the diploma work allowed to reach essential improvement of separate indicators of technological process of manufacturing of the case 00.01.003 A2.

The decisions made provided the possibility of concentration of processing, the organization of multi-machine service, mobility of production, as well as a significant reduction in the cost of equipping the production process

Selected designs of special machine tools made it possible to improve the quality of workmanship and reduce the preparatory and final time for operations.

A number of labor protection issues were also considered to ensure safe working conditions for staff and their significant improvement.

Calculations carried out in the organizational and economic part confirmed the correctness of the design decisions and showed that the introduction of a new technological process has reduced the cost of manufacturing parts, as well as improved a number of other technical and economic indicators.

REFERENCES

1. Anserov M.A. Devices for metal-cutting machines. M.: Mashinostroyeniye, 1975.
2. Antonyuk V.E. Handbook of the designer on the calculation and design of fixtures.-Minsk: Belarus, 1979.
3. Gorbatsevich A.F. and others. Course design for engineering technology.-Minsk.: Higher School, 1970.
4. Rud V.D. Course design of machine-building technologies: Navch. help - K.: ISDO, 1996 – 300 p.
5. Bozhenko L.I. Mechanical engineering technology. Design and manufacture of blanks. Lviv: World, 1996. 368 p.
6. Grabchenko A.I., Uzunyan M.D., Zubkova N.V. and others. Calculation of the most favorable modes of cutting when turning. Kharkiv NTU "KhPI" 2014. 87 p.
7. Grigurko I.O., Brendulya M.F., Dotsenko S.M. Technology of mechanical engineering. Diploma design: textbook. way. Lviv: New World, 2011. 768 p.
8. Jigerey V.S. Ecology and environmental protection: textbook. way. Kind. 2nd, p. Kyiv: Knowledge, 2002. 203 p.
9. Zharkov N.V., Prokdy R.G., Finkov M.V. AutoCAD 2014: manual. St. Petersburg: Science and Technology, 2014. 624 p.
10. Kapatsila Yu. B., Komar R.V., Dyachun A.E. Mechanical assembly sites and shops: textbook. way. Ternopil: TNTU, 2016. 40 p.
11. Kapatsila Yu. B., Komar R.V. Design of machine-building industries: textbook. way. Ternopil: TNTU, 2017. 40 p.
12. Palivoda Yu. Instrumental materials, cutting modes, technical standardization of mechanical processing: educational and methodical manual / Yu. Palivoda, A. Dyachun, R. Leschuk. - Ternopil, Ternopil National Technical University named after I. Pulyuy, 2019. – 240 p.
13. Matalin A.A. Technology of mechanical engineering.– L. - M.,1985. – 496 p.
14. Mirensky I.G. Fundamentals of mechanical engineering technology: textbook.

way. Kharkiv: KNAMG 207. 275 p.

15. Design and manufacture of machine parts blanks. Cast blanks: textbook. way. / JP Dusanyuk and others. Vinnytsia, 2009.199 p.
16. Loktev A.D. General engineering standards of cutting modes: a handbook. In 2 volumes. Moscow: Mechanical Engineering, 1991.
17. Solntsev Yu. P. Materials science: a textbook for universities. St. Petersburg: Khimizdat, 2007. 84 p.