The Ministry of Education and Science of the Russian Federation
Federal state autonomous educational institution of higher education
“**NATIONAL RESEARCH TOMSK POLYTECHNIC UNIVERSITY”**

The School of Advanced Manufacturing Technology
Major15.03.01 “Mechanical engineering”
Division for Materials Science

Bachelor work

Worktheme
Master schedule projection of the flange manufacturing   **(**Проектирование технологического процесса изготовления фланца**)**

UDC 621.643.412.002.2

Thestudent:

Group	**Last, Firstname**	**Signature**	**Date**
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Consultants (Advisers):

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Tomsk – 2018

RECOGNIZED SCHEDULE RESULTS of TRAINING
on SEP (Standard Educational Programmer)

Result code	Result of training (the graduate should be ready)
Professional competences	
R1	To apply profound natural-science, mathematical and engineering knowledge to creation and machining of new materials
R2	To apply profound knowledge in the field of modern technologies of engineering manufacture to the decision of interdisciplinary engineering problems
R3	To formulate and solve the innovative problems of the engineering assaying related with creation and machining of materials and articles, with use of the systems analysis and simulation of plants and machine industry processes
R4	To develop master schedules, to design and use the new equipment and instruments for machining of materials and articles, competitive in the world market of engineering manufacture
R5	To carry out theoretical and experimental researches in the field of the modern technologies of materials machining, Nano-technology, creations of new materials in complex and uncertain conditions
R6	To introduce, operate and serve modern hi-tech lines of a computer aided production, to ensure their high performance, to observe rules of health protection and a labor safety on engineering manufacture, to fulfill requirements on environment guard
Multiple-purpose competences	
R7	To use profound knowledge on design management for support of innovative engineering activity taking into account legal aspects of guard of intellectual property
R8	Actively to own a foreign language at the level, allowing to work in the environment speaking another language, to develop the documentation, to present and protect results of innovative engineering activity
R9	Effectively to work individually, as a member and the principal of the group consisting of experts of various directions and qualifications, to show responsibility for results of operation and readiness to follow corporate culture of organization (of enterprise)
R10	To show profound knowledge of social, ethical and cultural aspects of innovative engineering activity, competence of sustainable development questions
R11	Independently to learn and to raise continuously qualification during all period of professional work

РЕФЕРАТ

выпускной квалификационной работы

студента гр. 8Л4И Отокуефор Йероме Тцеи

«Проектирование технологического процесса изготовления фланца»

Выпускная квалификационная работа выполнена на 111с. пояснительной записки, содержит 56 рис., 12 табл., 13 источников, 2 листов прил.

Ключевые слова: фланца, припуск, технологический размер, размерный анализ, режим резания, технологический процесс, нормирование технологического процесса, закрепление фланца для сверление, пневматический цилиндр, расчёт приспособления, технологическая себестоимость, социальная ответственность.

Объектом исследования является технология изготовления детали “фланец”.

Цель работы – подтверждение квалификации «бакалавр техники и технологии» по направлению 15.03.01 «Машиностроение», по профилю подготовки «Технология, оборудование и автоматизация машиностроительных производств».

В процессе исследования проводились: анализ чертежа и технологичности детали, выбор заготовки, проектирование технологического процесса механической обработки детали “фланца”, расчёт припусков на обработку всех поверхностей, размерный анализ технологического процесса и расчёт технологических размеров, расчёт режимов резания и требуемой мощности станков, расчёт времени выполнения каждой операции и всего технологического процесса, проектирование специального приспособления для поворотная поверхность, расчёт необходимой силы закрепления, описание конструкции приспособления, расчёт технологической себестоимости изготовления детали, анализ вредных факторов на производстве и решение вопросов безопасности работы, действия при чрезвычайных ситуациях и мероприятия по их предотвращению, анализ влияния производственных факторов на окружающую среду.

В результате исследования был спроектирован технологический процесс и специальное приспособление, рассчитана технологическая себестоимость изготовления детали, которая составила 1552.83 руб., решены вопросы безопасности работы, разработаны мероприятия по предотвращению чрезвычайных ситуаций.

Основные конструктивные, технологические и технико-эксплуатационные характеристики: при организации крупносерийного производства штучно-калькуляционное время обработки одной детали составит 49,39 минут. Для производства детали «Фланец» потребуется следующее оборудование: токарный станок 16К20Ф3 и вертикально сверлильный станок 2М112.

Степень внедрения: по результатам защиты работы на государственной аттестационной комиссии будет решено, следует ли рекомендовать разработки к внедрению на производстве.

Область применения: производство машиностроительной продукции.

Экономическая значимость работы достаточно высокая.

В будущем планируется участвовать в организации производства детали.

THE ABSTRACT

Diploma Thesis

Of the student Otokuefor Jerome Tseyi, gr. 8Л4И

“Master schedule projection of the Flange”

Diploma Thesis is executed on 101 p. of the explanatory note, containing 56 fig. 12 tab., 13 references, 2 sheets in appendix.

Keywords: Flange, allowance, technological size, dimensional assaying, cutting mode, master schedule, master schedule valuation, clamping of flange for turning a surface, pneumatic cylinder, work-holding device calculation, technological cost price, social responsibility.

Object is the manufacturing technology of part “Flange”.

The operation purpose-qualification affirming «The bachelor of engineering and technology» in a major 15.03.01 “Mechanical Engineering” in a profile of training “Technique, the equipment and automation of engineering manufactures”.

During the research work were carried out: the assaying of the drawing and manufacturability of the part, an initial work-piece choice, projection of a master schedule of the part “Flange” machining, calculation of allowance in machining of all surfaces, the dimensional analysis of the master schedule and calculation of technological sizes, calculation of cutting mode and demanded power of machine tools, calculation of time of part machining of each operation and all master schedule, projection of special work-holding device for drilling, calculation of necessary force of fixing, the description of work-holding device, calculation of the technological cost price of manufacture of the part, the assaying of harmful factors on manufacture and the decision of safety issues of operation, operation at emergency situations and actions for their prevention, the assaying of influence of production factors on environment.

As a result of probe the master schedule and the special work-holding device have been designed, the technological cost price of manufacture of the part is calculated

Which is 1552.83 rub, operation safety issues are solved, and actions for prevention of emergency situations are developed.

The basic constructive, technological and technique-operational parameters: at business lot production the standard time of one part manufacturing will be 2.36 minutes. For the part “The flange” manufacturing is required following equipment: the lathe with 16К20Ф3 and the drilling machine 2М112.

Introduction degree: by results of defense of Diploma Thesis on the state certifying commission it will be solved, whether it is necessary to recommend workings out to introduction on manufacture.

Field of application: manufacture of engineering production.

Economic significance of Diploma Thesis is high enough.

In the future, it is planned to participate in organization of part manufacturing.

The Ministry of Education and Science of the Russian Federation

Federal state autonomous educational institution of higher education
“**National Research Tomsk Polytechnic University”**

School	The School of Advanced Manufacturing Technology (ScAMT)
Major	15.03.01 “Mechanical engineering”
Division of School	Division for Materials Science (DMS)

Approved
The Head of the Major
15.03.01 “Mechanical Engineering ajor

EfremenkovE.A..
«_____» ___. 2018

Assignment

For executing of final qualification work

In the form:

Bachelor Degree Project

To the student:

Group	**Name**
8Л4И	Otokuefor Jerome Tseyi (Отокуефор Йероме Тцеи)

Work theme:

Master schedule projection of the flange manufacturing **(**Проектирование технологического процесса изготовления фланца**)**	
It is approved by the director’s ScAMT order	N 1753/c «14» 03.2018

Deadline for submission of the final copy by the student	25.10.18

The technical task:

Initial data to work:	The detail drawing; the annual program of release N_a=7000 pieces
The list of section to research, designing and working out of questions:	
1. The technological part:	To execute the analysis of manufacture-ability of a detail; to prove of a initial blank choice; to design technological process; to calculate allowances for machining of all surfaces; to execute the dimensional analysis of technological process and to calculate the technological sizes; to calculate cutting modes and demanded power of machine tools, time for performance of each operation and all technological process
2. The design part:	To design the special fixture for one of operations; to define necessary force of a clamping; to write the design description

The list of a graphics:	1. The detail drawing - format A2; 2. Operational cards of technological process - format A1; 3. Complex scheme of the dimensional analysis - format A1 or A2; 4. The assembly drawing of a fixture – format A1 or A2; 5. The specification of an assembly drawing of a fixture – format A4; 6. Calculation of the technological cost of manufacturing of a detail - format A1.

Advisers for sections of final qualification work

Section	The Adviser
Technological part	Associate Professor of DMS Kozlov V.N.
Design part	Associate Professor of DMS Kozlov V.N.
Financial management	Senior Lecturer Potekhina N.V.
Social responsibility	Professor of Department of Control and Diagnostic Nazarenko O.B.
The summary in Russian and English languages	Associate Professor of DMS Kozlov V.N.

Names of sections which should be written in Russian and foreign (English) languages
The summary

Date when the individual assignment was issued to the student under the linear schedule	29.01.18

Individual assignment was issued to the student by the supervisor:

Post	**Name**	**Scientific degree, a rank**	**Signature**	**Date**
Associate Professor of Division for Materials Science	Kozlov V.N.	Ph.D. (Engineering), Associate Professor		29.01.2018

Date when the individual assignment was issued to the student:

Group	**Name**	**Signature**	**Date**
8Л4И	Otokuefor Jerome Tseyi		29.01.2018

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Introduction

Mechanical Engineering is a diverse discipline that encompasses the teaching and leadership of others in the development/upgrading and application of scientific principles to mechanical systems.

Mechanical engineering covers the ability to solve complex problems that deliver and optimize safe, sustainable and ethical solutions for design, manufacturing, and operation of mechanical devices schematics and systems involving mechanical component.

The main goal of this project is to learn and upgrade our skills in manufacturing complex part which specifically includes:

1. design of the part with some special mechanical software (COMPAS,SOLIDWORKS,NX90,AUTOCAD)
2. tolerance analysis
3. dimension chains in both radial and axial directions
4. calculating manufacturing sizes
5. calculating allowances
6. cutting parameters
7. standard time for manufacturing

Design holding device for our part to make it easier to locate in machining.

1. Manufacturing process design

1.1. Initial data

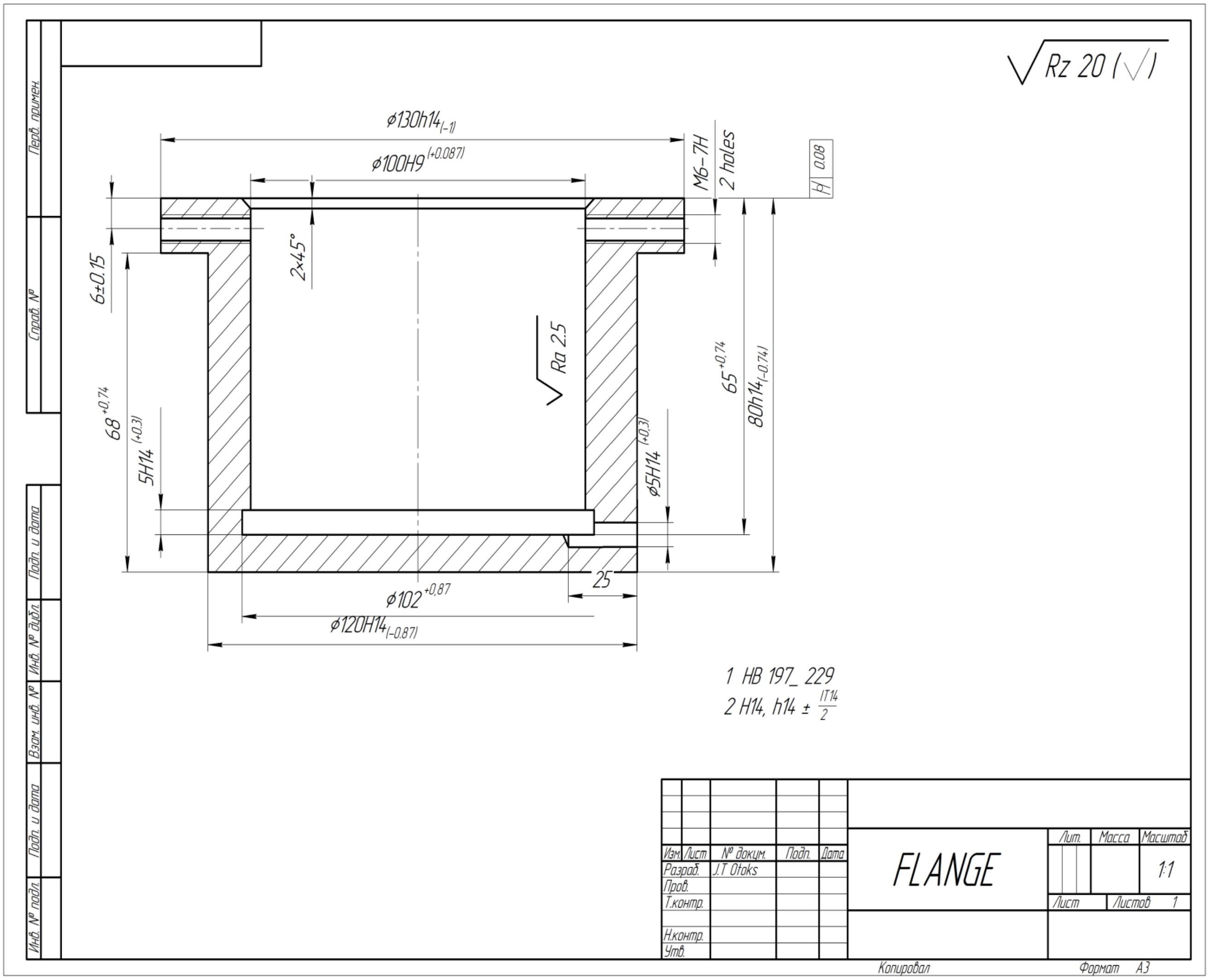


Fig.1. Sketch of the part “Flange”

1.2. Manufacturability Analysis

The part is made of steel 45Л which consists of 0.45% of C, 0.17% of Si, 0.5-0.8% of Mn. The hardness is HB is 197….229 measured with the help of Brinwell measuring scale. Heat treatment is not recommended because of the low hardness. Analyzing the dimensions, presence of precise holes and roughness implies the use of operations that ensure high accuracy. Cylindricity should not be more than 0.08. Production of the work-piece is carried out by die-forging where the metal is placed in a die resembling the mold which is attached to an anvil.

Selection of the workpiece

In selection of the workpiece, we need to take into consideration, the size of the workpiece, the material been used, volume of production etc.

The part been manufactured consist of diameter Ø$120_{-0.87}$ which is the outer diameter with accuracy grade h14 of the shaft. The part also includes the holes Ø100H9($^{+0.087}$) and Ø102H14($^{+0.87}$), the outer diameter Ø130h14 ($_{-1}$). The part also contains 2 threaded holes M6-7H and 1 hole without a thread. The material used is steel 45Л. The part is a medium batch production with annual program 7000 parts.

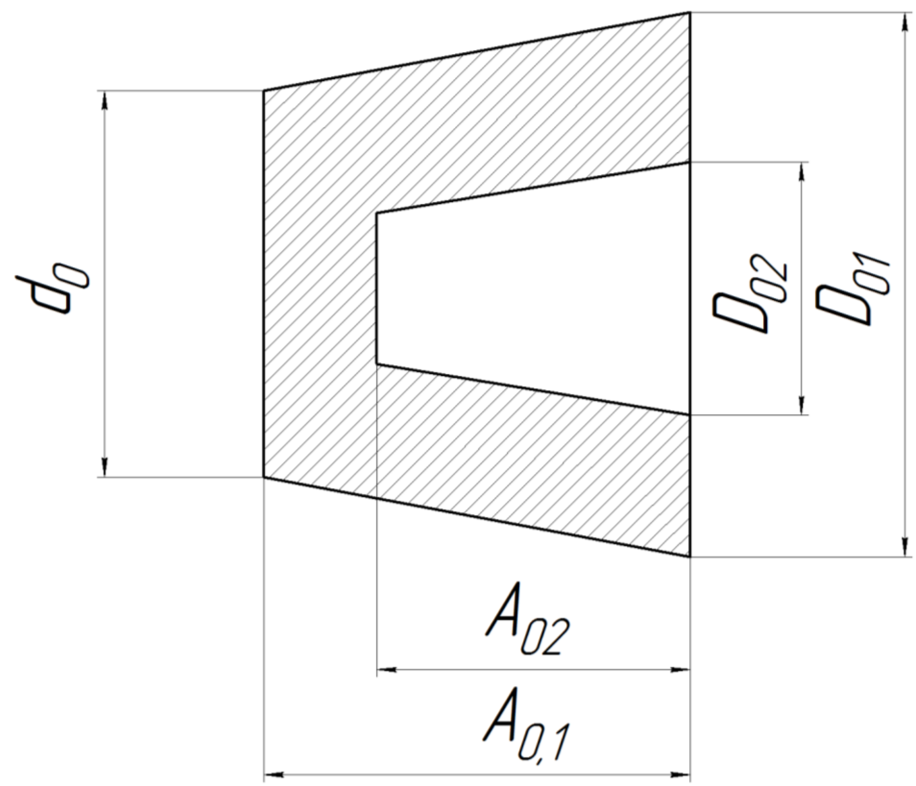


Fig.2. Sketch of the initial work-piece

1.3. Calculation of the production type

To determine the type of production at the stage of a design, it is necessary to evaluate the factor of manufacturing type.

Factor of manufacturing type is calculated as follows:

$$K_m=\frac{t_m}{T_{f(avg)}}, \quad (1)$$

where, t_m – is the cycle time [min];

$T_{f(avg)}$ – is an average unit cost calculation for manufacturing process, [min].

t_m is calculated as:

$$t_m=\frac{F_r \cdot 60}{N},$$

Where $F_г$ – an annual fund of operating time of the equipment, hours;

$N_г$ – total number of parts per year;

Then,

$$t_m=\frac{F_Г}{N_Г}=\frac{4015 \text{ X } 60}{7000}=34.4 \text{ min/piece}$$

Average unit cost calculation for manufacturing process is:

$$T_{f(avg)}=\frac{\sum_{i=1}^{n} T_f}{n} \quad (2)$$

where

T_f – is cost calculation for operations [min];

n – is number of operations.

Here the number of operations are 4 (n=5)

$$T_{f1}=\Phi_{к.i} \text{x } T_{oi} \quad (3)$$

Where $\Phi_{к.i}$ - is coefficient of operation depending on the type of the machine tools and anticipated production.

$T_{0.i}$- manufacturing time for the first operation in minutes.

Therefore, for the first operation (turning): $\Phi_{к.i}$=2.14;

For the second operation (turning): $\Phi_{к.2}$=2.14;

For the third operation (Drilling): $\Phi_{к.3}$=1.72;

For the fourth operation (Drilling): $\Phi_{к.4}$=1.72.

The machining time is calculated with the formula, where the time depends on the length and diameter of the machined surface and also on the method of manufacturing.

The machining time for the first operation we calculate for the longest step during the transition.

$T_{0.1}=0.052(D^2-d^{2)}) \times 10^{-3}$,

where D – is diameter before machining, [mm]

d – is diameter after machining, [mm].

Then:

$T_{0.1}=0.31(130^2-100^2) \times 10^{-3}=0.25$ [min]

$T_{0.1.2}=0.18 -100^2 \times 10^{-3}=1.17$ [min]

$T_{0.1.3}=0.3 -100 \times 65 =1.95$ [min]

$T_{0.1.4}=0.19(102^2-100^2) \times 10^{-3}=0.076$ [min]

Unit calculation time of the given operation can be calculated from formula (3):

$T_{f1}=\Phi_{к.i} \times T_{oi}= 2.14 \times 3.19 = 6$min

The machining time for the second operation with turning machine (16k20):

$T_{0.2.1}=0.037(120^2) \times 10^{-3}= 1$ min

$T_{0.2.2}=0.17 \times 120 \times 68 \times 10^{-3} = 1$ min

$T_{0.2.3}=0.17 \times 120^2 \times 12 \times 10^{-3} = 0$ min

Unit calculation time of the given operation can be calculated from formula (3):

$T_{f2}=\Phi_{к.2} \times T_{o2} =2.14 \times 2.11 = 4$ min

The machining time for the third operation with drilling machine (2M112):

$T_{0.3.1}$=0.52(5x15) X 10^{-3}=0.039min

$T_{0.3.2}$=0.52(5x15) X 10^{-3}=0.039min

Unit calculation time of the given operation can be calculated from formula (3)

$T_{f_3} = Ф_{к.3}$ x T_{o3} =1.72 x 0.78 = 1.3 [min]

The machining time for the fourth operation with drilling machine (2M112)

$T_{0.4}$=0.52 x 5 x 25 x 10^{-3} = 0.065

Unit calculation time of the given operation can be calculated from formula (3)

$T_{f_4} = Ф_{к.3}$ x T_{o4} =1.72 x 0.065 = 0.1 [min]

$$T_{f(avg)} = \frac{\sum_{i=1}^{n} T_{ш.ki}}{n} = \frac{T_{Ш.К1}+T_{Ш.К2}+T_{Ш.К3}+T_{Ш.К4}}{4} = \frac{6.8+4.51+1.3+0.1}{4} = 3.1 \text{ min}$$

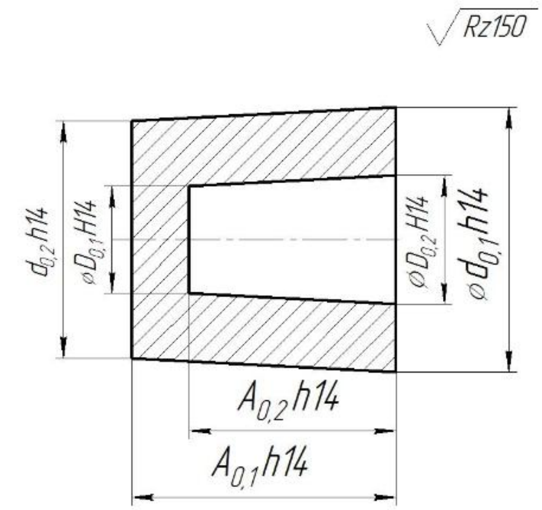
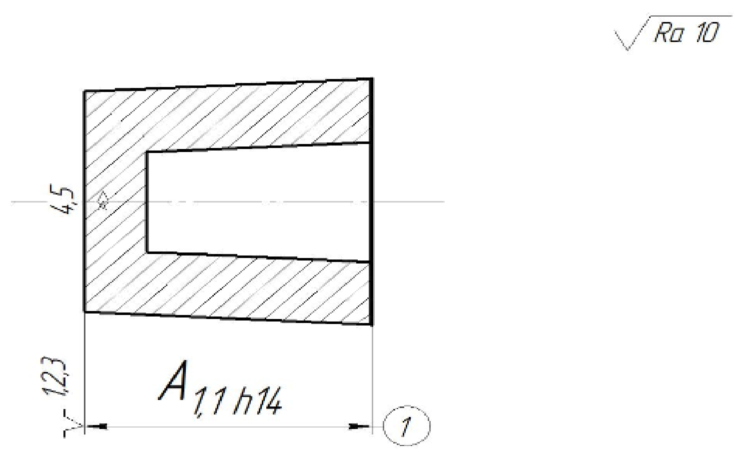
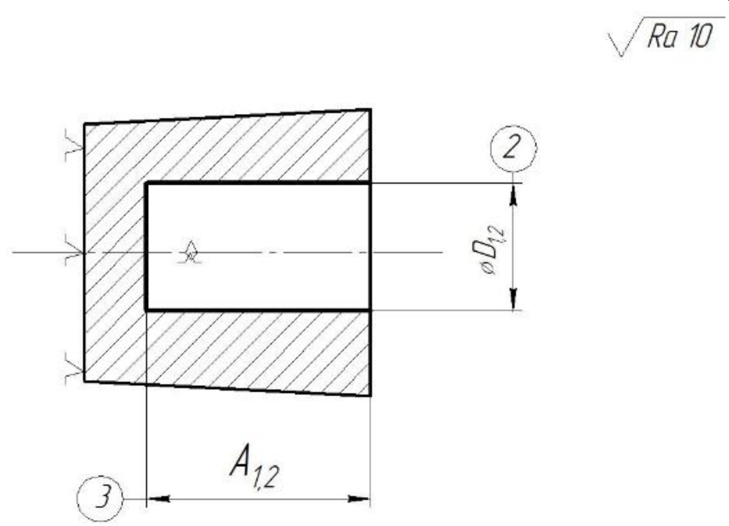
The coefficient of operations can be determined from the formula (1):

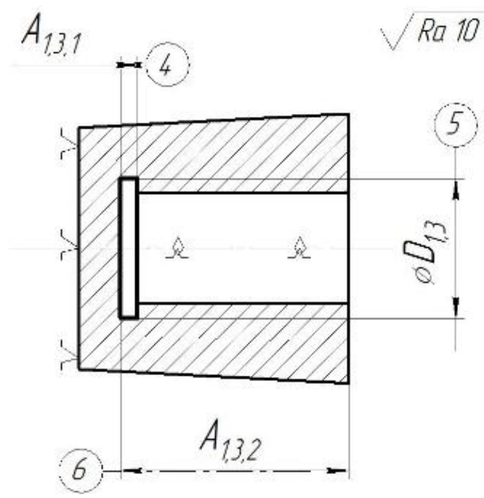
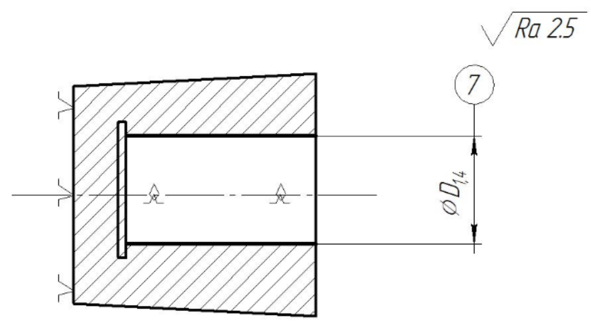
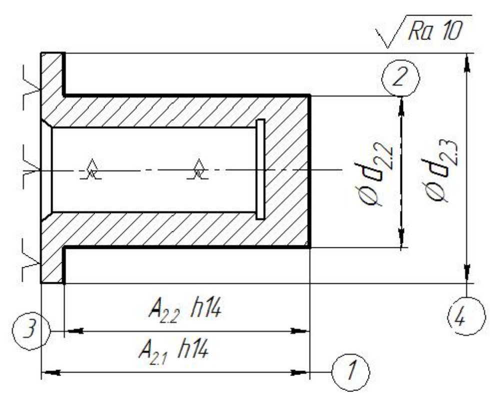
$$K_m = \frac{t_m}{T_{f(avg)}} = \frac{34.4}{3.1} = 11.1.$$

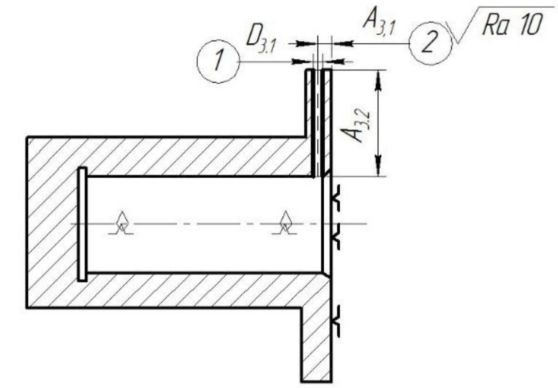
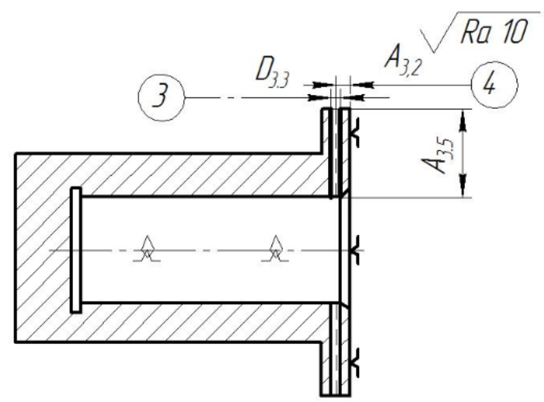
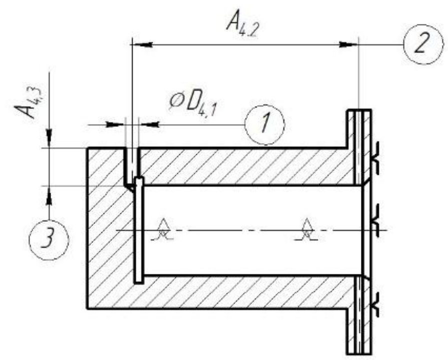
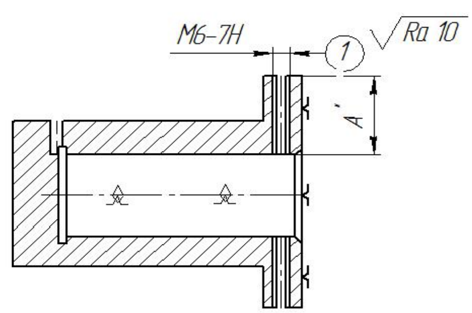
so, K_m= 10$< 11.1 < 20$ so the type of production is medium batch production.

1.4. Route of the manufacturing process

Table1.1 Route of the manufacturing process

. 0	1	forge the work-piece ensuring sizes $Ød_{0.1}$, $Ød_{0.2}$, $ØD_{0.1}$ $ØD_{0.2}$ with 14 grade of tolerance	
1	0 1	Mount and clamp/unclamp work piece Cut face (1) ensuring size $A_{1.1}h14$.	
	2	Rough bore hole (2) previously ensuring $ØD_{1.2}H12$ and size $A_{1.2}Js14$.	

	3	Bore groove (4) $A_{1.3.1}$ ensuring sizes (5) $ØD_{1.3}$ and (6) $A_{1.3.2}$	
	4	Semi-finish bore hole (7) $ØD_{1.4}$ = =Ø100H9($^{+0.087}$) on a pass (on a length 62*)	
2	0 1 2 3	Clamp/unclamp Machine face (1) ensuring sizes $A_{2.1}$ h14 Machine external surface (2) $ød_{2.2}$, ensuring sizes (3) $A_{2.2}$ h14 Machine external surface (4) $Ød_{2.3}$h14 on a pass	

3	A 0 1	 Mount and clamp a workpiece in a work-holding attachment with a jig conductor Drill hole (1) on a pass ensuring size (2)	
	B 2 3	Unclamp the work-piece, rotate it on 180°. Clamp the workpiece Drill the hole (3) ensuring size (4) Unclamp the workpiece and take it off	
4	 0 1 2	 Mount and clamp a workpiece in a work-holding attachment with a jig conductor Drill the hole (1) ensuring sizes (2) and (3) Unclamp the workpiece and take it off	
5	A 0 1 B 2 3	 Clamp a workpiece Cut thread holes (1) on a pass Rotate the workpiece Cut thread in hole ensuring size 2 Unclamp the workpiece and take it off	

1.5. Tolerance Analysis of the Manufacturing Process

Tolerances of dimensions of the initial blank are in accordance with the standards and reference materials. We cannot just write anything we want but the tolerances of the sizes obtained in each machining operation are determined with the help of accuracy tables. These tables contain statistical data with respect to roughness, sizes of products manufactured on various metal-working machine.we have to state the dimensional Analysis for axial and radial direction. The dimensional diagram is shown in the figure below.

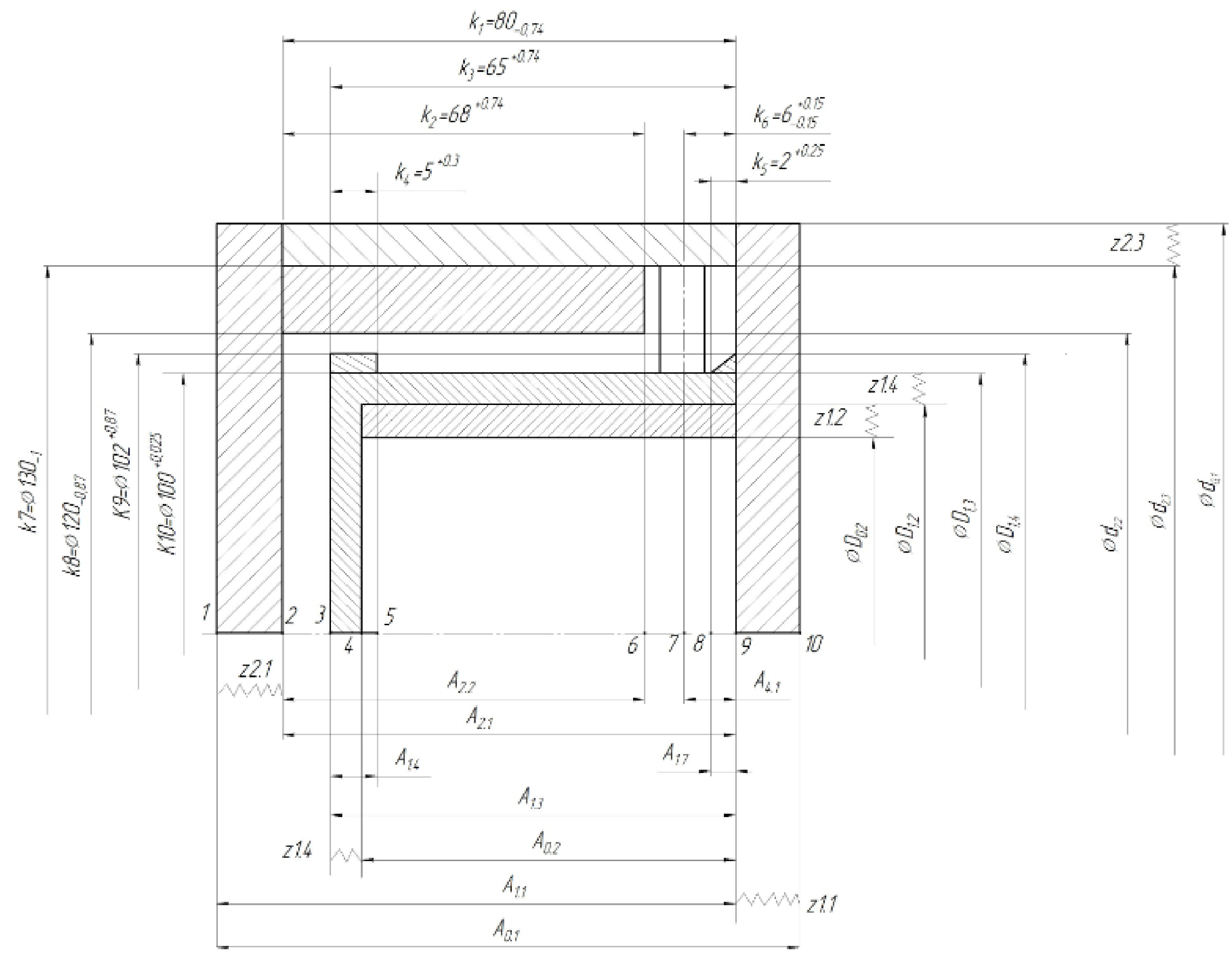


Fig.3. Dimensional diagram

In this scheme the number of surfaces is 10, the number of manufacturing sizes is 9, the number of allowances is 3 and the number of design dimensions is 6. Therefore, the dimensional scheme is correctly constructed. In-order to abate the compilation of dimensional chains, a graph tree is constructed on the basis of the dimensional diagram.

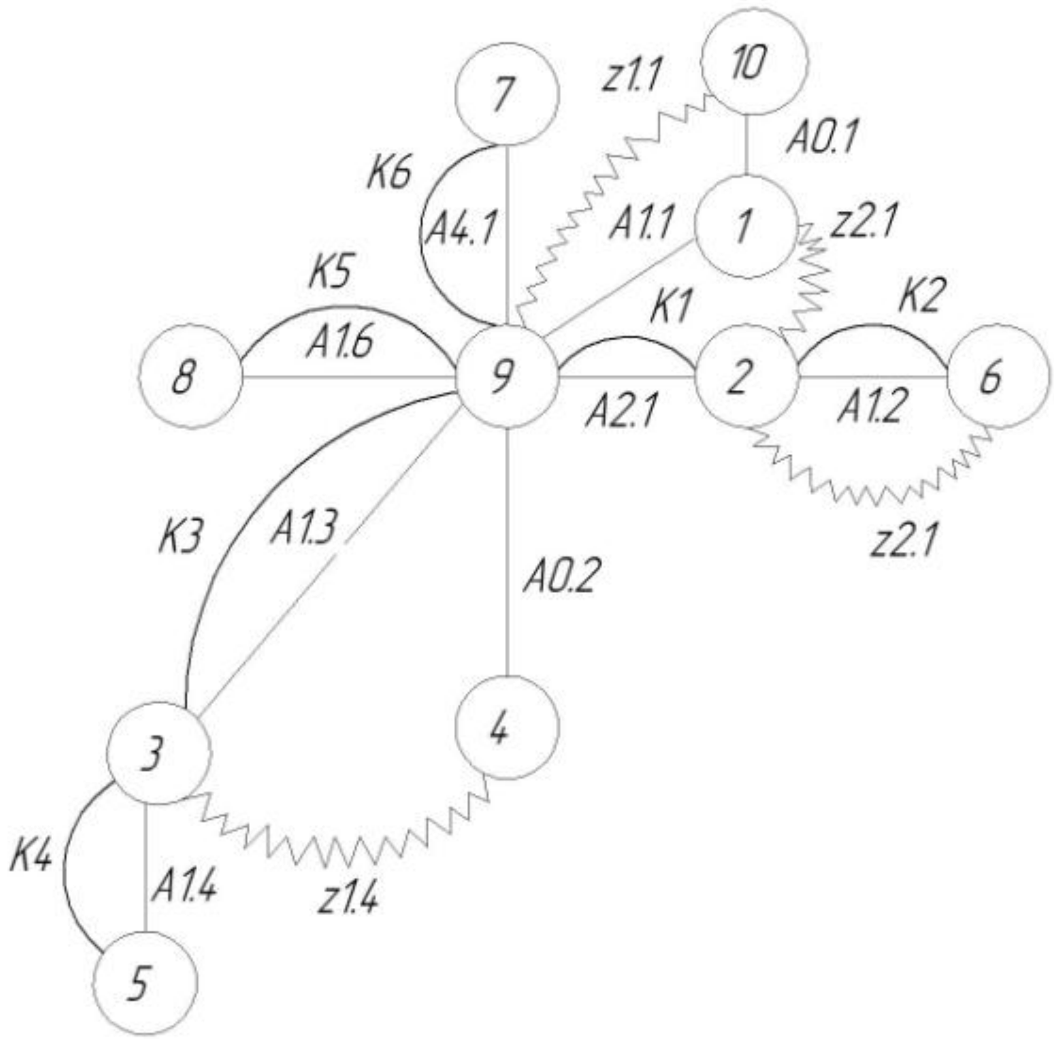


Fig.4. Graph-tree for manufacturing dimensional chains

1.5.1. Dimensional analysis in the axial direction

The tolerances of K-sizes are as follows:

Tk_1= 074 mm;

Tk_2=0.74 mm;

Tk_3= 0.74 mm;

Tk_4= 0.3 mm;

Tk_5=0.25 mm;

Tk_6= 0.3 mm.

Tolerances of manufacturing sizes are calculated with the following equation:

$TA_i=\omega_{ci}+\rho_i$

Tolerances of manufacturing sizes, A-sizes:

$TA_{1.1}$=0.2+0.120=0.32 mm;

$TA_{1.3}$=0.2 mm;

$TA_{1.4}$=0.2 mm;

$TA_{1.6}$=0.2 mm;

$TA_{2.1}$=0.2+0.08 =0.28 mm;

$TA_{2.2}$=0.2 mm;

$TA_{4.1}$=0.15+0.08=0.23 mm;

$TA_{0.1}$=0.8 mm;

$TA_{0.2}$=0.8 mm.

Dimension chains for K-sizes are given below.

Dimension chain for the size K_1 is shown in Fig. 5.

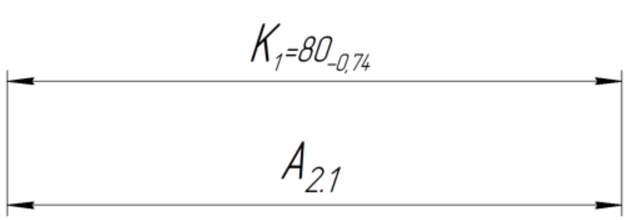


Fig.5. Dimension chain for calculation of manufacturing size $A_{2.1}$ relatively design size K_1

TK_1=0.74 mm; $TA_{2.1}$=0.28 mm. K_1 is directly ensured.

Dimension chain for the size K_2 is shown in Fig. 6.

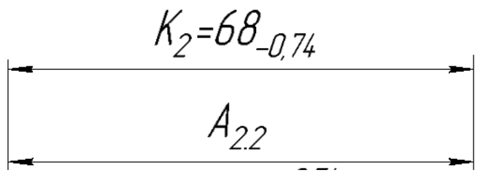


Fig.6. Dimensional chain for calculation of manufacturing size $A_{2.2}$ relatively design size K_2

TK_2= 0.74 mm; $TA_{2.2}$=0.2 mm. K_2 is directly ensured.

Dimension chain for the size K_3 is shown in Fig. 7.

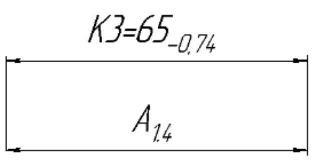


Fig.7. Dimensional chain for calculation of size $A_{1.4}$ relatively design size K_3

Tk_3 = 0.74 mm

$TA_{1.4}$ = 0.28 mm

K_3 is directly ensured

Dimensional chain for the size K_4 is shown in Fig. 8

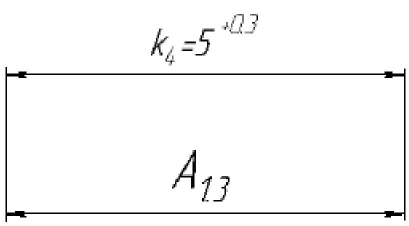


Fig.8. Dimensional chain for calculation of size $A_{1.3}$ relatively design size K_4

Tk_4=0.3mm

$TA_{1.3}$=0.2mm, K_4 is directly ensured.

Dimensional chain for the size K_5 is shown in Fig.9

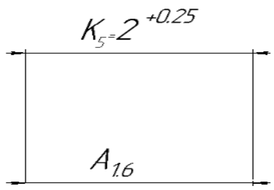


Fig.9. Dimensional chain for calculation of size $A_{1.6}$ relatively design size K_5

Tk_5 = 0.25 mm; $TA_{1.6}$ = 0.2 mm; K_5 is directly ensured

Dimensional chain for the size K_6 is shown in Fig. 10

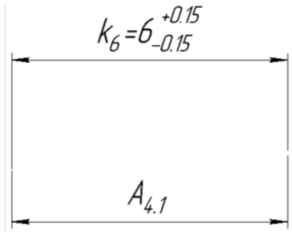


Fig.10. Dimensional chain for calculation of size $A_{4.1}$ relatively design size K_6

TK_6 = 0.3 mm; $TA_{4.1}$ = 0.23mm. K_6 is directly ensured.

1.5.2. Tolerance analysis in radial direction

Tolerances of manufacturing sizes in radial direction are taken from the table

Tolerances of manufacturing sizes, D-sizes:

TD_{01}=0.8 mm;

TD_{02}=0.8 mm;

$TD_{1.2}$=0.35 mm;

$TD_{1.3}$=0.087 mm;

$TD_{1.4}$=0.87 mm;

$TD_{2.2}$=0.87 mm;

$TD_{2.3}$=1.0 mm.

The tolerances of K-sizes:

Dimensional chain for the size K_7 is shown in Fig. 11

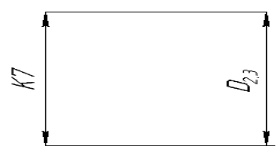


Fig.11. Dimensional chain for calculating for calculation of size $D_{2.3}$ relatively design size K_7

TK_7= 1.0 mm; $TD_{2.3}$=1.0 mm. K_7 is directly ensured in radial direction.

Dimensional chain for the size K_8 is shown in Fig. 12

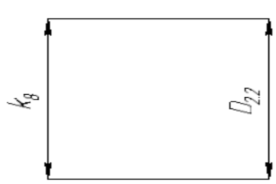


Fig.12. Dimensional chain for calculation of size K_8

Tk_8=0.87mm; $TD_{2.2}$=0.87mm; K_8 is directly ensured in axial direction.

Dimensional chain for the size K_9 is shown in Fig. 13

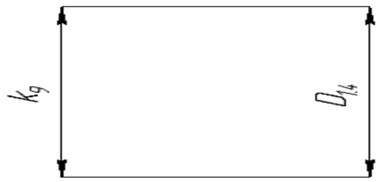


Fig.13. Dimensional chain for calculation of size k_9

TK_9= 0.87 mm; $TD_{1.4}$=0.84 mm; K_9 is directly ensured in axial direction.
Dimensional chain for the size K_{10} is shown in Fig. 14

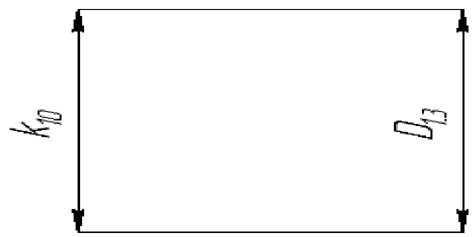


Fig.14 Dimensional chain for calculation of size K_{10}

TK_{10}= 0.087 mm. $TD_{1.3}$=0.087mm. K_{10} directly ensured in radial direction.

1.6. Calculation of allowances

In manufacturing processes, for example in turning operation or milling operation, an allowance is the volume of material to be removed. This explains the concept of allowances to be the amount of materials removed during machining.

The allowances for processing the work-piece are selected depending on the economically accepted method of machining, the configuration of product and its weight. Calculation of allowances can be made by statistical and analytical method.

The analytical method consists of the analysis of production errors that occurs under specific conditions when machining the work-piece, determines the values of elements that make up the allowance and their summation. Dedendum allowance is removal of excessive materials to obtain a particular size.

Table 1.2. Calculation of allowances and technological sizes

Name of machining	Elements of allowances				Allowance 2_{zmin}	Accepted size d_p, mm	Tolerances T, mkm	Calculated dimensions, mm	
	R_z	T	ρ	ε				d_{min}	d_{max}
ø100H9									
Stamped blank H14	150	200	90			96.9H14	800	96.92	97.72
Rough boring H12	50	60	25	200	2×790= 1580	99,3H12	350	99.33	99.68
Semi-finish boring H9	10	30	40	0	320	100H9	87	100	100,087
$K_1 = 80h14_{-0,74}$									
Stamped blank h14 (side A)	150	200	90			82,5h14	740	81,74	82,48
Turn side A (h14)	50	60	25	200	540	81,2h14	740	80,44	81,18
Stamped blank Side B (h14)	150	200	90						
Turn side B(h14)	50	60	25	100	440	80h14	740	79,26	80
Length of the part $K_2 = 68h14_{-0,74}$									
Stamped blank h14 Side A	150	200	100			70,6 h14	740	69,85	70,59
Turn side A	50	60	25	200	650	69,2h14	740	68,44	69.18
Stamped blank h14 Side B	150	200	90						
Turn side B	50	60	25	100	440	68h14	740	67,26	68
Name of machining	R_z	T	ρ	ε	2_{zmin}	d_{accept}, mm	T, µm	A_{min}	A_{max}
Depth of the hole (ø100H9) A_K=65H14									
Stamped blank h14 (side A) $A_{0.2}$H14	150	200	100			64.5H14	740	**63.75**	64.49
Depth of the hole after machining side A (it is **not measured**)	50	60	25	200	650	**63.1**H14	740	63.025	**63.765**
Rough bore side C with the length $A_{1.2}$	50	60	25	0	335	**64.1**H14	740	64.125	**64.865**
Bore groove on the side C $A_{1.3}$= K=65H14	50	60	25	0	135	**65**H14	740	65	65.74
$Ø130h14_{-1}$									
Stamped blank	150	200	90			$Ø131,9h14$	1000	130,88	131,88
Rough turning $Ø130h14$	50	80	60	160	880	130h14	1000	129	130

1.6.1. Calculation of allowances in axial direction

The minimum, maximum and average allowance for axial direction is determined by the formula:

$$Z_{i\ min}= (Ra_{i-1}+h_{defi-1}+\rho_{i-1}+ \varepsilon_i)\ [\mu m], \qquad (1.1)$$

where z_{min} – minimum allowance for machining the given surface [μm];

Ra_{i-1} – roughness of the surface of the previous step [μm];

h_{defi-1}– thickness of the defective layer from the previous step [μm];

ρ_{i-1} – geometrical error of the previous step [μm].

Allowance $z_{1.2}$:

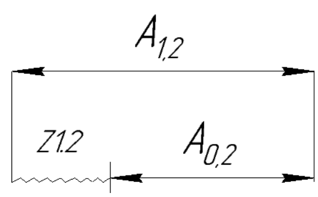


Fig.15. Dimension chain for calculation of **size $A_{0.2}$**

Calculation of minimum allowance for boring the groove (4) in the hole $ØD_{1.2}$H12 on the length $A_{1.3}$H14 $z_{1.3\,min}$:

$z_{1.3\ min}$ = 50+60+25+0 = 135 μm = 0.135 mm.

$z_{1.3\ max} = z_{1.3\ min} + TA_{1.3} + TA_{1.2}$ = 0.135+0.74+0.74 = 1.615 mm.

$z_{1.3av}=\frac{z_{1.3min}+z_{1.3max}}{2} = \frac{0.135+1.615}{2}$= 1.0 mm.

Distance $A_{1.3.2}$ of the groove $A_{1.3.1}$ with $ØD_{1.3}$H14 in processing step 3 of the operation 1 is equal: $\mathbf{A_{1.3.2}}$ = 65H14.

Distance $A_{1.2}$ of the bored hole $ØD_{1.2}$H14 in processing step 2 of the operation 1 is equal: $\mathbf{A_{1.2}}$ = 64.1H14.

Calculation of minimum allowance for distance $A_{1.2}$ in rough boring the hole $ØD_{1.2}$H12 ($z_{1.2.l}$ for length $A_{1.2}$) is not necessary, since it is surplus of a material on the length.

Allowance $z_{1.1}$.

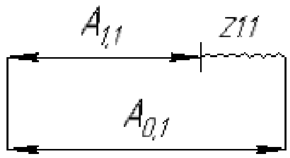


Fig.16. Dimension chain for calculation of **size $A_{0.1}$**

Calculation of minimum allowance for $z_{1.1\min}$ (Cut face (1) ensuring size $A_{1.1}$h14, for ensuring length 68h14 of the part):

$Z_{1.1_{min}} = (150 + 200 + 100 + 200) = 540\ \mu m$ =0.54 mm.

Maximum allowance for $z_{1.1\max}$ is:

$Z_{1.1_{max}} = z_{1.1\min} + (TA_{1.1}+TA_{0.1}) = 0.54+0.74+0.74 = 2.02$ mm.

Calculation of average allowance for $z_{1.1av}$:

$z1.1av = \frac{Z_{1.1_{min}}+z_{1.1_{max}}}{2} = \frac{0.54+2.02}{2} = 1.28$ mm.

Allowance $z_{2.1}$ (Cut face (1) ensuring size $A_{2.1}$h14, for ensuring length 68h14 of the part):

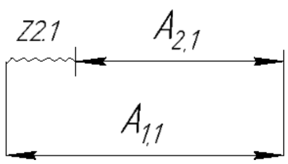


Fig.17. Dimension chain for calculation of **size $A_{2.1}$**

Calculation of minimum allowance for $z_{1.2\min}$:

$Z_{2.1_{min}} = (150 + 200 + 100 + 100) = 450\ \mu m$ =0.45 [mm],

Maximum allowance for $z_{2.1\max}$:

$Z_{2.1max} = Z_{2.1_{min}} + (TA_{1.4}+TA_{0.2}) = 0.44+0.74+0.74 = 1.92$ mm

Calculation of average allowance for $z_{2.1av}$:

$z_{2.1av} = \frac{Z_{2.1_{min}}+z_{2.1_{max}}}{2} = \frac{0.45+1.92}{2} = 1.185$ mm.

1.6.2. Calculation of allowances in radial direction

Since we use 3-jaw chuck, the minimum, maximum and average allowance for radial direction (in machining a hole or a shaft) is determined by the formula:

$$2z_{i\,min} = 2(Ra_{i-1}+h_{defi-1}+\rho_{i-1}+ \varepsilon_i) \qquad (1.2)$$

Allowance $2z_{1.2}$:

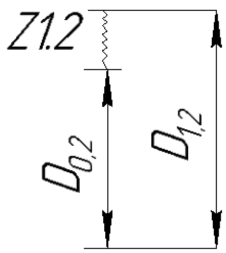


Fig.18 Dimension chain for calculation of **size $D_{0.2}$**

Calculation of minimum allowance $2z_{1.2\text{min}}$ in rough boring the hole (2) ensuring size Ø$D_{1.2}$H12 (for ensuring Ø100H9 of the part):

$$2Z_{2.1_{min}} = 1580\ \mu m$$

Maximum allowance for $2z_{1.2\text{max}}$:

$Z_{1.2_{max}}$=$2Z_{1.2_{min}}$ + $TD_{0.2}$+$TD_{1.2}$ = 1580+800+350= 2730 μm

Calculation of average allowance for $z_{1.2av}$:

$z_{1.2av} = \frac{Z_{1.2_{min}}+z_{1.2_{max}}}{2} = \frac{1,58+2.73}{2}$= 2.155 mm.

Allowance $2z_{1.4}$:

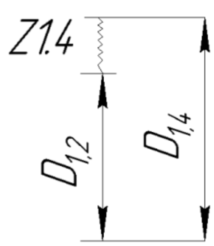


Fig.19. Dimension chain for calculation of **size $D_{1.4}$**

Calculation of minimum allowance $2z_{1.4\min}$ in semi-finish boring the hole (7) Ø$D_{1.4}$H9 for ensuring Ø100H9 of the part:

$2Z_{1.4_{min}} = 2(50 + 50 + 60 + 0) = 320$ μm = 0.32 [mm],

Maximum allowance for $2z_{1.4\max}$:

$Z_{1.4_{max}}$=$2Z_{1.4_{min}}$ + $TD_{1.2}$+$TD_{1.3}$ = 0.32+0.35+0.087=0.757mm.

Calculation of average allowance for $z_{1.2av}$:

$z_{1.4av} = \frac{Z_{1.4_{min}}+z_{1.4_{max}}}{2} = \frac{0.32+0.757}{2}$= 0.535 mm.

Allowance $2z_{2.3min}$:

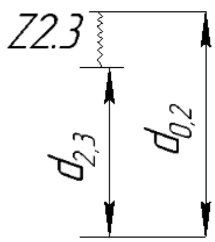


Fig.20. Dimension chain for calculation of **size $d_{2.3}$**

Calculation of minimum allowance 2 $z_{2.3\min}$ in rough turning external cylindrical surface (4) (a shaft) Ø$d_{2.3}$h14 for ensuring Ø130h14 of the part:

$2Z_{2.3_{min}} = 2(150 + 200 + 90 + 160) = 1200\ \mu m$ = 1.2 [mm],

Maximum allowance for $2z_{2.3\max}$:

$2Z_{2.3_{max}}$=$2Z_{2.3_{min}}$ + $Td_{0.2}$+$Td_{2.3}$ = 1.2+1.0+1.0 = 3.2 mm

Calculation of average allowance for $z_{2.3av}$:

$z_{2.3av} = \frac{Z_{2.3_{min}}+z_{2.3_{max}}}{2} = \frac{1.2+3.2}{2}$= 2.2 mm.

Allowance $2z_{2.2min}$:

Dimension chain for calculation of **size $d_{2.2}$** in rough turning external cylindrical surface (2) (a shaft) Ø$d_{2.2}$h14 for ensuring Ø120h14 of the part:

$2Z_{2.2_{min}} = 2(150 + 200 + 90 + 160) = 1200\ \mu m$ = 1.2 mm.

Maximum allowance for $2z_{2.2}$:

$2Z_{2.2_{max}} = 2Z_{2.3_{min}} + Td_{0.1} + Td_{2.2}$ = 1.2+1.0+1.0=3.2 mm.

Calculation of average allowance for $z_{2.2av}$:

$z_{2.2av} = \frac{z_{2.3_{min}} + z_{2.3_{max}}}{2} = \frac{1.2+3.2}{2} = 2.2$ mm.

But it is not necessary to calculate allowance $2z_{2.2min}$ as $2z_{2.2}$ is not allowance, it is surplus of a material on the external diameter Ø$d_{2.2}$, because the diameter Ø$d_{2.2}$h14 is much less Ø$d_{2.3}$h14 and especially Ø$d_{0.2}$h14.

Calculation of allowance $2z_{2.2min}$ might be obligatory if initial stamped blank has the same external configuration as the part “Flange”.

1.6.3. Calculation of manufacturing sizes in axial direction

Enumerating manufacturing sizes (technological sizes) of axial direction is determined from the tolerance analysis in axial direction of the manufacturing process. Calculation of manufacturing sizes in axial direction therefore includes:

1. The manufacturing size $A_{2.1}$ is equal to the design size K_1

$K_1^{av}=80_{-0.74}=79.63\pm0.37$

2. The manufacturing size $A_{1.6}$ is equal to the design size K_3

$K_3^{av}=65\pm0.37$

3. The manufacturing size $A_{2.2}$ is equal to the design size K_2

$K_2^{av}=68\pm0.37$

4. The manufacturing size $A_{1.4}$ is equal to the design size K_4

$K_4^{av}=5.15\pm0.15$

5. The manufacturing size $A_{1.6}$ is equal to the design size K_5

$K_5^{av}=2.125\pm0.172$

6. The manufacturing size $A_{4.1}$ is equal to the design size K_6

$K_6^{av}=6.15\pm0.15$.

1.6.4. Calculation of manufacturing sizes which are not equal to design sizes in axial direction

For manufacturing size $A_{0.1}$;

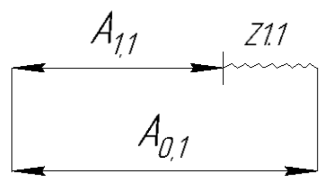


Fig.21.The calculation of technological size $A_{0.1}$

$A_{0.1}^{av}=A_{1.1}^{av}+z_{1.1}^{av}$; $A_{0.1}^{av}=81.15\pm0.4=81.55_{-0.8}$; $A_{0.1}\approx81.6_{-0.8}$ mm.

For manufacturing size $A_{0.2}$;

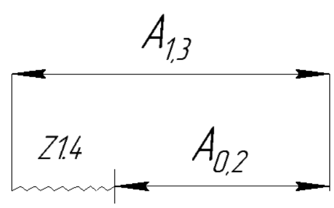


Fig.22.The calculation of technological size $A_{0.2}$

$A_{0.2}^{av}=A_{1.3}^{av}-z_{1.4}^{av}$; $A_{0.2}^{av}=65-0.185=67.06\pm0.4$; $A_{0.2}\approx64.81\pm0.4$ mm.

For manufacturing size $A_{1.1}$;

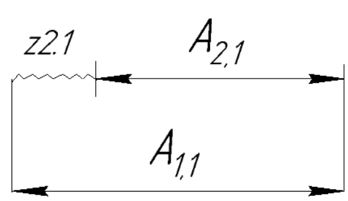


Fig.23.The calculation of technological size $A_{1.1}$

$A_{1.1}^{av}=A_{2.1}^{av}-z_{2.1}^{av}$; $A_{1.1}^{av}=79.63+0.52=80.15\pm0.16\approx80.3_{-0.32}$

1.6.5. Calculation of manufacturing sizes which are not equal to design sizes in radial direction

In radial direction we have to calculate the manufacturing sizes, which is partially obtained from the average constructional sizes in radial direction and from making a chain in radial direction with respect to the allowance.

Calculation of manufacturing sizes in radial direction therefore includes;

1. The manufacturing size $D_{2.3}$ is equal to the design size K_7

K_7^{av}=129.5±0.50 mm.

2. The manufacturing size $D_{2.2}$ is equal to the design size K_8

K_8^{av}=119.5±0.44 mm.

3. The manufacturing size $D_{1.4}$ is equal to the design size K_9

K_9^{av}=102.435±0.435 mm.

4. The manufacturing size $D_{1.3}$ is equal to the design size K_{10}

K_{10}^{av}=100.0435.5±0.435 mm.

Technological size Ø$D_{1.2}$:

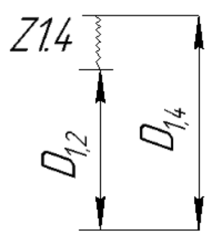


Fig.22.The calculation of technological size $D_{1.2}$

$D_{1.2}^{av}=D_{1.4}^{av}-2z_{1.4}^{av}$ =100.0435-0.535 = 99.5085 mm.

$D_{1.2}^{av}$=99.5±0.175 ≈99.5±0.17 mm.

Technological size $D_{0.2}$ (the hole in the stamped blank):

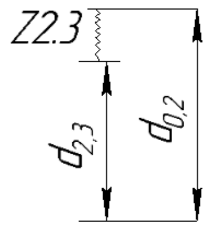


Fig.23.The calculation of technological size $D_{0.2}$

$D_{0.2}^{av}=D_{1.2}^{av}-2z_{1.2}$ = 99.5-2.155 = 97.345 mm;

$D_{0.2}$ =96.7±0.37 mm = $95.9^{+0.8}_{-0.4}$ mm.

Technological size Ø $d_{0.2}$ (the **minimal** size of **external conical** surface of the stamped blank) (for the design size ØdK2 = 130h14).

$d_{0.2}^{av}=d_{2.3}^{av}+2z_{2.3}^{av}$ =129.5+2.2 = 131.7 mm. $d_{0.2}$=131.7±0.5 = $131.3^{+0.4}_{-0.8}$ mm.

1.7. Calculation of cutting parameters

Calculating of cutting modes includes:

1. depth of cut
2. feed rate
3. cutting speed
4. spindle rotation,[n]

The depth of cut in most cases is equal to the allowance in axial/radial direction. Thereafter we choose the feed rate from the book of mechanical engineering part 2 [3].

TURNING OPERATION WITH 16K20: FACING $A_{1.2}$ = 80h14$_{(-0.74)}$

The cutting tool material been used is T15K6 selected in accordance with the recommendations from table 3[p 116]. Ø$D_{0.1}$H14 = 90.14H14, Ø$d_{0.1}$ = 136.9h14

Turning face-end surface from Ø$d_{0.1}$h14 to Ø$D_{0.2}$H14 in operation 1.

Initial data (from the table 1.2): Ø$d_{0.2}$ = 131.9h14, Ø$D_{0.2}$ = 96.9H14; $A_{0.1}$ = 70.6h14, $A_{0.2}$ = 64.5H14. It is necessary to calculate diameters of stamped blank taking into account angles of a stamping slope α.

Maximal diameter of the **external conical** surface (on the right side of the blank in the sketch of operation 0) Ø$d_{0.1\ max}$ = $d_{0.2\ max}$ + 2×$A_{0.1\ max}$×tgα $_{extenal}$ = 131.9 + + 2×70.6×tg2°= 131.9+4.93 = 136.83 ≈ 136.9 mm; Ø$d_{0.1accepted}$ = 136.9h14.

Minimal diameter of the **conical hole** near the bottom (on the right side of the blank's hole in the sketch of operation 0) Ø$D_{0.1min}$ = Ø$D_{0.2min}$ - 2×$A_{0.2\ max}$×tgα $_{internal}$ = = 96.9 - 2×64.5×tg3° = 96.9 - 6.76 = 90.14 mm. Ø$D_{0.1acceptd}$ = 90.1H14.

Minimal diameter of the conical hole on the right side of the blank after 1-st processing step of 1-st operation (after facing**)** Ø$D_{1.1}$ ≈ Ø$D_{0.2}$ = 96.9 mm due to small allowance which is removed in facing in 1-st processing step of 1-st operation ($z_{1.1}$ = 0.54…2.02 mm).

1. The depth of cut for facing is equal to the maximum machine allowance:

$$t = z_{1.1} = 2.02 \text{ mm}$$

2. Feed rate chosen from table 11 which is within the range S=0.8…1.3 mm/rev [3, table 14]; but from the table 14 (nose radius r=1.2 mm, roughness of the machined surface Rz40 mkm) S = 0.63 mm/rev [3, table 14], therefore $S_{accepted}$= 0.6 mm/rev.
3. The cutting speed is determined by the formula:

$v = \frac{v}{T^M t^x s^y} k_v$

where,

1. T – tool life (30mins);
2. t – depth of cut (mm);
3. S – feed rate (mm/rev).

Coefficient: C_V =350; x=0.15; y=0.35; m=0.2 chosen from table 17.

Coefficient K_v:

$K_v=K_{MV}*K_{PV}*k_{iV}$

Where,

K_{MV} – factor, taking into account the quality of processed materials

K_{PV} – coefficient reflecting the state of the surface of the work-piece

k_{iV} – Is a coefficient that considers the quality of the tool material

According to the table 3, [p261:

$$K_{MV} = K_{\Gamma} \left(\frac{750}{\sigma_B}\right)^{n_v}$$

The values of coefficient K_{MV} and exponential power n_v due to the material of the tool which is hard alloy is chosen from the [table2 p.262]:

$$K_{\Gamma} = 1 \; n_v = 1$$

Therefore,

$$K_{MV} = K_{\Gamma} \left(\frac{750}{\sigma_B}\right)^{n_v} = 1 \left(\frac{750}{1000}\right)^{1} = 0.75$$

Finally, the coefficient K_v is:

$K_v = K_{MV} * K_{PV} * k_{iV} = 0.75 \times 0.8 \times 1 = 0.60$.

Therefore, the cutting speed V:

4. $v = \frac{C_V}{T^M \times t^x \times s^y} \cdot K_V = \frac{350}{30^{0.2} \cdot 2.02^{0.15} \cdot 0.6^{0.35}} \cdot 0.6 = 78$ m/min.

5. Calculation of the number of spindle rotation:

$n = \frac{100 \cdot V}{\Pi \cdot d} = \frac{78 \cdot 1000}{3.14 \cdot 136.9} = 181$ rev/min, $n_{accepted} = 160$ rev/min.

$v = \frac{\pi \cdot d \cdot n}{1000} = \frac{\pi \cdot 137 \cdot 160}{1000} = 68.8$ m/min.

6. Determining the force P_z by the formula :

$P_Z = 10 \cdot c_p \cdot t^x \cdot s^y \cdot v^n \cdot k_p$

$C_p = 300$; $n = -0.15$; $y = 0.75$; $x = 1$ chosen from table 22, p.273.

Coefficient $K_p = \left(\frac{\sigma_B}{750}\right)^{n_v} = \left(\frac{1000}{750}\right)^{0.75} = 1.24$

Therefore,

$P_Z = 10 \cdot c_p \cdot t^x \cdot s^y \cdot v^n \cdot k_p = 10 \cdot 300 \cdot 2.02^1 \cdot 0.6^{0.75} \cdot 68.8^{-0.15} \cdot 1.24 = 3944$ N

7. Cutting power:

$N_e = \frac{p_z \cdot V}{1020 \cdot 60} = \frac{3944 \cdot 68.8}{1020 \cdot 60} = 4.43$ kW

Power of machine tool: $N_m = N_e \times K_{ensurance} = 4.43 \times 1.3 = 5.76$ kW.

We choose lathe 16K20 (N=11 kW).

TURNING OPERATION WITH 16K20: GROOVE CUTTING with width $A_{1.3.1}$

The cutting tool material been used is T15K6 selected in accordance with the recommendations from table 3 [p116].

The depth of cut for grooving is equal to the length of the cutter:

$$t = 5 \text{ mm}$$

Feed rate chosen from table 11 which is within the range =0.16…0.23 mm/rev, therefore $S_{accepted} = 0.2$ mm/rev (table 12)

The cutting speed is determined by the formula:

$v = \frac{v}{T^M \times s^y} \times$ k_v

where,

T - Tool life=30mins

t - Depth of cut

S - Feed rate,

Coefficient: C_V =47; y=0.8; m=0.2 chosen from table 17.

Coefficient K_v: $K_v=K_{MV}\times K_{PV}\times k_{iV,}$

Where,

K_{MV} – is factor, taking into account the quality of processed materials;

K_{PV} – coefficient reflecting the state of the surface of the work-piece;

k_{iV} – is a coefficient that takes into account the quality of the tool material.

According to the table 3, p261:

$$К_{MV} = К_{Г}\left(\frac{750}{σ_{B}}\right)^{n_v}$$

The values of coefficient $К_{MV}$ and exponential power n_v due to the material of the tool which is hard alloy is chosen from the [table2 p.262]:

$$К_{Г} = 1, n_v = 1$$

Therefore,

$$К_{MV} = К_{Г}\left(\frac{750}{σ_{B}}\right)^{n_v} = 1\left(\frac{750}{1000}\right)^{1} = 0.75$$

Finally, the coefficient K_v is :

$K_v=K_{MV}*K_{PV}*k_{iV}=0.75\times0.8\times1=0.60$

Therefore, the cutting speed V:

$v = \frac{C_V}{T^M \times s^y} \cdot K_V = \frac{47}{15^{0.2} \cdot 0{,}2^{0.8}} \cdot 0.60$ =102 m/min

Calculation of the number of spindle rotation:

n=$\frac{1000 \cdot V}{\Pi \cdot d} = \frac{105 \cdot 1000}{3.14 \cdot 102} = 327\,\frac{\text{rev}}{\text{min}}$.

n $_{standard}$= 315 rev/min

$v=\frac{\Pi dn}{1000}=\frac{3.14\cdot 102\cdot 315}{1000}=100\ \text{m/min}.$

TURNING OPERATION WITH 16K20: FACING $A_{2.1}$

Tool material been used is T15K6 selected in accordance with the recommendations from [3, p 116].

The depth of cut for facing is equal to the maximum machine allowance:

$$t=z_{2.1\ max}=1.92\ \text{mm}$$

Feed rate chosen from table 11 which is within the range S=0.8…1.3 mm/rev [3, table 14]; but from the table 14 (nose radius r=1.2 mm, roughness of the machined surface Rz≤40 mkm) S = 0.63 mm/rev [3, table 14], therefore $S_{accepted}$= 0.6 mm/rev.

The cutting speed is determined by the formula:

$v=\frac{v}{T^M t^x s^y}\times k_v$

where,

T – tool life=30min.

t – depth of cut, mm.

S – feed rate, mm/rev.

Coefficient: C_V =350; x=0.15; y=0.35; m=0.20 [3, table 17]

Coefficient K_v:

$K_v=K_{MV}*K_{PV}*k_{iV}$

Where,

K_{MV} – is a factor, taking into account the quality of processed materials;

K_{PV} – is a coefficient reflecting the state of the surface of the work-piece;

k_{iV} – is a coefficient that takes into account the quality of the tool material.

According to the table 3 [p261]

$$K_{MV}=K_{\Gamma}\left(\frac{750}{\sigma_B}\right)^{n_v}$$

The values of coefficient $К_{MV}$ and exponential power n_v due to the material of the tool which is hard alloy is chosen from the table2 [p262]:

$$К_{Г} = 1 \; n_{v} = 1$$

Therefore,

$$К_{MV} = К_{Г} \left(\frac{750}{\sigma_{B}}\right)^{n_{v}} = 1 \left(\frac{750}{1000}\right)^{1} = 0.75.$$

Finally, the coefficient K_v is:

$K_v = K_{MV} * K_{PV} * k_{iV} = 0.75 \times 0.8 \times 1 = 0.60$.

Therefore, the cutting speed V:

$$v = \frac{C_V}{T^M t^x s^y} \cdot K_V = \frac{350}{30^{0.2} \cdot 1.92^{0.15} \cdot 0.6^{0.35}} \cdot 0.60 = 78 \text{ m/min}$$

Calculation of the number of spindle rotation:

$$n = \frac{1000 \cdot V}{\Pi \cdot d} = \frac{78 \cdot 1000}{3.14 \cdot 131.9} = 188 \text{ rev/min}, \quad n_{accepted} = 160 \text{ rev/min}.$$

$$v = \frac{\pi \cdot d \cdot n}{1000} = \frac{\pi \cdot 132 \cdot 160}{1000} = 66.3 \text{ m/min}.$$

Determining the force P_z by the formula:

$P_Z = 10 \cdot c_p \cdot t^x \cdot s^y \cdot v^n \cdot k_p$

$C_p = 300$; $n = -0.15$; $y = 0.75$; $x = 1$ chosen from table 22, p.273.

Coefficient $K_p = \left(\frac{\sigma_B}{750}\right)^{n_v} = \left(\frac{1000}{750}\right)^{0.75} = 1.24$

Therefore,

$P_Z = 10 \cdot c_p \cdot t^x \cdot s^y \cdot v^n \cdot k_p = 10 \cdot 300 \cdot 1.92^1 \cdot 0.6^{0.75} \cdot 68.8^{-0.15} \cdot 1.24 = 3850$ N

8. Cutting power:

$$N_e = \frac{p_z \cdot V}{1020 \cdot 60} = \frac{3850 \cdot 66.3}{1020 \cdot 60} = 4.17 \text{ kW}$$

Power of machine tool: $N_m = N_e \times K_{ensurance} = 4.17 \times 1.3 = 5.42$ kW.

We choose lathe 16K20 (N=11 kW), as for 1-st operation.

TURNING OPERATION: external turning Ø$d_{2.2}$=120h14$(_{-0.87})$.mm on the length $A_{2.2}$ = 68H14.

Tool material been used is T15K6 selected in accordance with the recommendations from [3, p 116].

$d_{2.2}$=120 mm, $d_{0.1}$=136.9h14$(_{-1.0})$. Since $A_{2.2}$ = 68H14 ≈ $A_{2.1}$ =80h14 we accept that $d_{0.1.2 \text{ on the length 68 mm}}$ ≈ Ø$d_{0.1}$ = 136.9h14$(_{-1.0})$.

The maximum allowance: $z_{max}=(d_{0.1max}-d_{2.2min})/2$= (136.9 – 119.13)/2= 8.85 mm.

Allowance should be removed for three passes (i = 3 passes). The depth of cut t_i will be different: for the 1-st pass t_1=3.5 mm; for the 2-nd t_2=3.5 mm.

For the 3-rd pass t_3=8.85-2×3.5 = 1.85 mm in order to reduce cutting force on the latest pass and increase accuracy.

Feed rate chosen from table 11 which is within the range S=0.8…1.3 mm/rev [3, table 14]; but from the table 14 (nose radius r=1.2 mm, roughness of the machined surface Rz≤40 mkm) S = 0.63 mm/rev [3, table 14], therefore $S_{accepted}$= 0.6 mm/rev.

The cutting speed is determined by the formula:

$$v = \frac{v}{T^M t^x s^y} \times k_v$$

where,

T - tool life=30mins

t - depth of cut

S - feed rate,

Coefficient: C_V =350; x=0.15; y=0.35; m=0.20 chosen from [3, table 17]

Coefficient K_v:

$K_v=K_{MV}*K_{PV}*k_{iV}$,

Where,

K_{MV} – is a factor, taking into account the quality of processed materials;

K_{PV} – is a coefficient reflecting the state of the surface of the work-piece;

k_{iV} – is a coefficient that takes into account the quality of the tool material

According to the table 3 [p261]

$$К_{MV} = К_{Г}\left(\frac{750}{\sigma_{В}}\right)^{n_{v}}$$

The values of coefficient $К_{MV}$ and exponential power n_v due to the material of the tool which is hard alloy is chosen from the table 2 [p262]:

$$К_{Г} = 1 \; n_{v} = 1$$

Therefore,

$$К_{MV} = К_{Г}\left(\frac{750}{\sigma_{В}}\right)^{n_{v}} = 1\left(\frac{750}{1000}\right)^{1} = 0.75$$

Finally, the coefficient K_v is:

$K_v = K_{MV} * K_{PV} * k_{iV} = 0.75 \times 0.8 \times 1 = 0.6$

Therefore, the cutting speed V:

$v = \frac{C_V}{T^M \times t^x \times s^y} \cdot K_V = \frac{350}{30^{0.2} \cdot 3.5^{0.15} \cdot 0.6^{0.35}} \cdot 0.60 = 68$ m/min.

Calculation of the number of spindle rotation:

$n = \frac{1000 \cdot V}{\Pi \cdot d} = \frac{68 \cdot 1000}{3.14 \cdot 120} = 180$ rev/min, $n_{accepted} = 160$ rev/min

$v = \frac{\Pi d n}{1000} = \frac{3.14 \cdot 120 \cdot 160}{1000} = 60.28$ m/min.

TURNING OPERATION WITH 16K20: ROUGH BORING Ø99,5H12

The part is rough bored during turning operation № 1. Cutting modes for boring are as follows: the cutting tool material been used is T15K6 selected in accordance with the recommendations from [3, p. 116].

Diameter of minimum hole in the bottom $ØD_{0.1} = ØD_{0.2} - 2 \times A_{0.2\,max} \times tg\alpha_{internal} =$ $= 96.9 - 2 \times 64.5 \times tg3° = 96.9 - 6.76 = 90.14$ mm.

Diameter of minimal hole on the **right** side of the blank in 1-st processing step of 1-st operation after facing $ØD_{1.1} \approx ØD_{0.2} = 96.9$ mm due to small allowance which is removed in facing in 1-st processing step of 1-st operation ($z_{1.1} = 0.54…2.02$ mm).

Initial data (from table 1.2) in rough boring the hole $ØD_{1.2} = 99.3H12(^{+0.35})$:

$Ød_{0.2}$ = 131.9h14, $ØD_{0.2}$ = 96.9H14; $A_{0.1}$ = 70.6h14; $ØD_{0.1accepted}$ = 90.1H14.

Maximal allowance which is removed in boring hole in 2-nd operation step $z_{1.2max} = (ØD_{1.2\,max} - ØD_{0.1\,min})/2 = (99.65-90.1)/2 = 4.775$ mm.

Accepted depth of cut: 1st pass t = 3 mm; 2nd pass t = 1.8 mm.

$t_{accepted}$ = 3 mm.

Feed rate chosen from table 12. Therefore, $S_{accepted}$=0.5 mm/rev [3, table 12].

The cutting speed is determined by the formula:

$v = \frac{v}{T^M t^x s^y}$x k_v

where,

T – is tool life (30 min);

t – is a depth of cut, mm;

S – is a feed rate, mm/rev.

Coefficient: C_V =350; y=0.35 x=0.15; m=0.2 chosen from [3, table 17]

Coefficient K_v:

$$K_v = K_{MV} * K_{PV} * k_{iV},$$

where,

K_{MV} – factor, taking into account the quality of processed materials;

K_{PV} – is a coefficient reflecting the state of the surface of the work-piece;

k_{iV} – is a coefficient that takes into account the quality of the tool material.

According to the [3, table 3, p. 261]

$$К_{MV} = К_{Г}\left(\frac{750}{σ_{В}}\right)^{n_v}$$

The values of coefficient $К_{MV}$ and exponential power n_v due to the material of the tool which is hard alloy is chosen from the [table2 p.262]:

$$К_{Г} = 1 \; n_v = 1$$

Therefore,

$$К_{MV} = К_{Г}\left(\frac{750}{σ_{В}}\right)^{n_v} = 1\left(\frac{750}{1000}\right)^{1} = 0.75$$

Finally, the coefficient K_v is :

$K_v=K_{MV}*K_{PV}*k_{iV}=0.75\times0.8\times1= 0.60.$

Therefore, the cutting speed V:

$v=\frac{v}{T^M t^x s^y}\cdot K_V=\frac{350}{30^{0.2}3^{0.15}0.5^{0.35}}\cdot 0.6= 151$ m/min.

Calculation of the number of spindle rotation:

$n=\frac{1000\cdot V}{\Pi\cdot d}=\frac{151\cdot1000}{3.14\cdot99.3}=484\ \frac{rev}{min};$

$n_{accepted}=400$ rev/min;

$v=\frac{\Pi dn}{1000}=\frac{3.14\cdot99.3\cdot400}{1000}=124\ \mathrm{m/min}$

As depth of cut t_{max} =3 mm in rough boring $ØD_{1.2}$=99.5H12 slightly less depth of cut in rough external surface $Ød_{2.2}$=120h14 (t_{max}=3.5 mm), we accept the same cutting power and choose lathe 16K20.

TURNING OPERATION WITH 16K20:SEMI-FINISH BORING $ØD_{1.4}$=Ø100H9

Tool material been used is T15K6 selected in accordance with the recommendations from [3, p. 116].

The depth of cut for semi-finishing boring is equal to the average machine allowance:

$z_{1.4} = (D_{1.4} – D_{1.2})/2 = (100^{+0.87} – 99.3^{+0.35})/2 = (0.7^{+0.87}_{-0.35})/2 = 0.35^{+0.44}_{-0.18}$ mm.

$z_{1.4max}$ = 0.35+0.44 = 0.79 mm. $z_{1.4\ min}$ = 0.35-0.18 = 0.17 mm.

$z_{1.4av} = (z_{1.4\ max} + z_{1.4\ min})/2$ = (0.79+ 0.17)/2 = 0.48 mm.

$t_{av}= z_{1.4av}$ = 0.48 mm.

r=0.8 mm (nose radius).

Feed rate chosen from [3, table 11] which is within the range S=0.2…0.9 mm, S=0.2 mm/rev, therefore $S_{accepted}$=0.2 mm/rev [3, table 14]

The cutting speed is determined by the formula:

$v=\frac{C_V}{T^M t^x s^y}$ x k_v

where: T - tool life, $T_{accepted}$ =30 min; t - depth of cut (mm); S – feed rate (mm/rev).

Coefficient: C_V =420; x=0.15; y=0.2; m=0.20 chosen from [3, table 17]

Coefficient K_v: $K_v=K_{MV}*K_{PV}*k_{iV}$

where,

K_{MV} – factor, taking into account the quality of processed materials;

K_{PV} – is a coefficient reflecting the state of the surface of the work-piece;

k_{iV} – is a coefficient that takes into account the quality of the tool material.

According to the [3, table 3, p. 261]

$$К_{MV} = К_{Г}\left(\frac{750}{\sigma_{B}}\right)^{n_{v}}$$

The values of coefficient $К_{MV}$ and exponential power n_v due to the material of the tool which is hard alloy is chosen from the [table2 p.262]:

$$К_{Г} = 1 \; n_{v} = 1$$

Therefore,

$$К_{MV} = К_{Г}\left(\frac{750}{\sigma_{B}}\right)^{n_{v}} = 1\left(\frac{750}{1000}\right)^{1} = 0.75$$

Finally, the coefficient K_v is:

$K_v=K_{MV}*K_{PV}*k_{iV}=0.75\times1x1= 0.75$.

Therefore, the cutting speed V:

$v = \frac{C_V}{T^M t^x s^y} \cdot K_V = \frac{420}{30^{0.2} \cdot 0.48^{0.15} \cdot 0.2^{0.2}} \cdot 0.75 = 464$ m/min

Calculation of the number of spindle rotation:

n=$\frac{1000 \cdot V}{\Pi \cdot d} = \frac{464 \cdot 1000}{3.14 \cdot 100} = 1477.7$ rev/min

$n_{accepted}$=1250 rev/min

v=$\frac{\Pi d n}{1000} = \frac{3.14 \cdot 100 \cdot 1250}{1000} = 385$ m/min.

As depth of cut t_{max} =0.79 mm in semi-finish boring $ØD_{1.4}$=100H9 less depth of cut in rough boring $ØD_{1.2}$=99.5H12 (t_{max}=3 mm) we accept the same cutting power and choose lathe 16K20.

DRILLING OPERATION: Drill 2 HOLES Ø4.6H12 for the thread M6-7H and 1 hole Ø5H12

Calculate cutting mode for the maximal diameter d_{hole}=5 mm,

length of hole l = (130-100)/2= 15 mm. Ratio K_l = l/D = 15/5 = 3 – is a normal length.

Feed rate chosen from table 11 which is within the range S=0.1-0.15 rev/min.

Therefore, $S_{accepted}$=0.1 mm/rev [table 25]

The Cutting speed is determined by the formula:

$v = \frac{C_V D^q}{T^M S^y} \times k_v$

Where,

T – is tool life, T=15 min [table 30].

S – is feed rate,

Coefficient: C_V =7; y=0.7; m=0.20; q=0.4chosen from [table 28]

Coefficient K_v:

$K_v = K_{MV} \times K_{PV} \times k_{iV}$

Where,

K_{MV} – is a factor, taking into account the quality of processed materials;

K_{PV} – is a coefficient reflecting the state of the surface of the work-piece;

k_{iV} – is a coefficient that takes into account the quality of the tool material.

According to the table 3 [p. 261]

$$K_{MV} = K_\Gamma \left(\frac{750}{\sigma_B}\right)^{n_v}$$

The values of coefficient K_{MV} and exponential power n_v due to the material of the tool which is hard alloy is chosen from the [table2 p.262]:

$$K_\Gamma = 1 \; n_v = 1$$

Therefore,

$$K_{MV} = K_\Gamma \left(\frac{750}{\sigma_B}\right)^{n_v} = 1\left(\frac{750}{1000}\right)^1 = 0.75$$

Finally, the coefficient K_v is:

$K_v=K_{MV}*K_{lV}*k_{iV}=0.75\times1\times1=0.75$.

Therefore, the cutting speed V:

$$v=\frac{C_V\cdot D^q}{T^M\cdot s^y}kv=\frac{7\cdot5^{0.4}}{15^{0.2}\cdot0.1^{0.7}}0.75=30\ m/min$$

Calculation of the number of spindle rotation:

$n=\frac{100\cdot V}{\Pi\cdot d}=\frac{30\cdot1000}{3.14\cdot5}=1911$ rev/min

$n_{accepted}=1100$ rev/min

$v=\frac{\Pi dn}{1000}=\frac{3.14\cdot5\cdot1100}{1000}=17.27$ m/min

Calculation the Torque (M_{KP}):

$M_{KP}=10_{CM}D^qS^yk_p$

$C_m=0.035$

$q=2.0$

$y=0.8$

K_p is taken from [3, table 9, p. 264]

$K_P=0.8$

Therefore the maximum Torque is derived by the formula:

$M_{KP}=10\times C_{M\times}D^q\times S^y\times K_p=10\times0.0345\times5^2\times0.1^{0.8}\times0.75=0.1$ Nm.

Cutting power:

$N_e=\frac{\text{м}\kappa_p\cdot V}{9750}=\frac{0.1\cdot17}{9750}=0.0174$ KW

Thread Cutting M6-7H

Using high speed steel tap. Feed rate will be equal pitch P. Therefore, S=P=0.75 mm.

The cutting speed is determined by the formula:

$v=\frac{C_VD^q}{T^Ms^y}\times k_v$

Where,

T - tool life (30min); S - feed rate, mm/rev.

Coefficient: $C_v=64.8$; y=0.5; m=0.9; q=1.2 chosen from [table 49, p.296]

Coefficient K_v:

$K_v = K_{MV} * K_{PV} * k_{iV}$,

Where,

K_{MV} – factor, taking into account the quality of processed materials;

K_{PV} – coefficient reflecting the state of the surface of the work-piece;

k_{iV} – is a coefficient that takes into account the quality of the tool material.

According to the table 3 [p261]

$$К_{MV} = К_{Г}\left(\frac{750}{σ_{В}}\right)^{n_v}$$

The values of coefficient $К_{MV}$ and exponential power n_v due to the material of the tool which is hard alloy is chosen from the [table2 p.262]:

$$К_{Г} = 0.95;\ n_v = 0.9$$

Therefore,

$$К_{MV} = К_{Г}\left(\frac{750}{σ_{В}}\right)^{n_v} = 0.95\left(\frac{750}{1000}\right)^{0.9} = 0.73$$

Finally, the coefficient K_v is:

$K_v = K_{MV} * K_{PV} * k_{iV} = 0.73 \times 1 \times 1 = 0.73$.

Therefore, the cutting speed V:

$$v = \frac{C_V \cdot D^q}{T^{M \cdot} s^y} kv = \frac{64.8 \cdot 6^{1,2}}{30^{0.9 \cdot} 0.75^{0.5}} 0.73 = 20\,\frac{\mathrm{m}}{\mathrm{min}}.$$

Calculation of the number of spindle rotation:

n=$\frac{1000 \cdot V}{\Pi \cdot d} = \frac{20 \cdot 1000}{3.14 \cdot 6} = 1000\ \mathrm{rev/min}$

For cutting thread with a **tap** $n_{accepted}$= 250 rev/min.

v=$\frac{\Pi d n}{1000} = \frac{3.14 \cdot 5 \cdot 250}{1000} = 3.9\ \mathrm{m/min}$

Calculating the Torque M_{KP}: it is not necessary to calculate for tapping thread M6-7H because it is very small and power of a drill press will be enough.

1.8. Calculation of standard time of manufacturing

The standard time for manufacturing gives us the exact time in which the part is manufactured. The standard time includes:

0. operation time
1. auxiliary time
2. time of rest
3. operation cycle time
4. set uptime

For turning operation machining time T_m is calculated by the formula

$$T_m = \frac{L \cdot i}{n \cdot S}, \text{ min}$$

Where,

L - the calculated manufacturing length, mm;

i - number of working strokes;

n - the frequency of rotation, rev/min;

S - feed rate, mm/rev.

Calculated manufacturing length (Fig. 10.1):

$L = l_{app} + l_{eng} + l + l_{over}$

Where,

l - is the length of the part;

l_{app} - it's the approach of the tool to the workpiece;

l_{eng} - the engagement length;

l_{over} - over-travel of the tool.

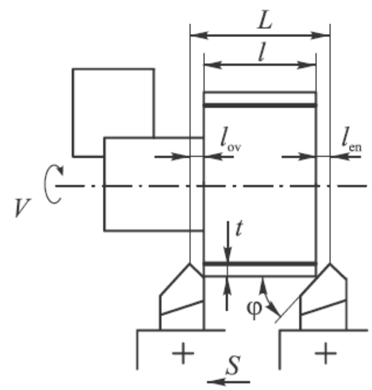


Fig.10.1. Diagram for calculation of the estimated cutting distances during turning [1]

Machining time for turning face-end surface from $Ød_{0.1}$ = 136.9h14 to $ØD_{0.1}$H14 = 90.14H14 in operation 1:

Initial data (from table 1.2): $Ød_{0.2}$ = 131.9h14, $ØD_{0.2}$ = 96.9H14; $A_{0.1}$ = 70.6h14.

It is necessary to calculate **diameter** of stamped blank taking into account angles of a stamping slope α:

$Ød_{0.1\ max} = d_{0.2\ max} + 2×A_{0.1\ max}×tgα_{\ extenal} = 131.9 + 2×70.6×tg2° = 131.9+4.93 = 136.83 ≈ 136.9$ mm; $Ød_{0.1} = 136.9h14$;

Diameter of minimum hole in the bottom $ØD_{0.1} = ØD_{0.2} - 2×A_{0.2\ max}×tgα_{\ internal} =$

$= 96.9 - 2×64.5×tg3° = 96.9 - 6.76 = 90.14$ mm.

Diameter of minimum hole on the **right** side of the blank in 1-st processing step of 1-st operation after facing $ØD_{1.1} ≈ ØD_{0.2} = 96.9$ mm due to small allowance which is removed in facing in 1-st processing step of 1-st operation ($z_{1.1} = 0.54…2.02$ mm).

That is why the length of the transference (shift) of a cutter in facing from

$Ød_{0.1} = 136.9h14$ to $ØD_{0.2} = 96.9H14$in operation 1:

$l_{facing}= (Ød_{0.1\ max} - ØD_{0.2})/2 = (136.9-90.14)/2 = 23.38$ mm. n=500 rev/min, s=1 mm/rev.

$T_{m1}= (1+1+23.8+1)/(500×1) = 0.053$ min.

In rough boring the hole $ØD_{1.2} = 99.3H12(^{+0.35})$.

Maximal allowance which is removed in boring hole in 2-nd operation step

z1.2 = $(ØD_{1.2\ max}-ØD_{0.2\ min})/2 = (99.65-96.9)/2 = 1.375$ mm.

For **rough boring of the hole $ØD_{1.2}$**=99.3H12 on the length $A_{1.2}$= 64.1H14:

$T_{m2}=\frac{1+1+64.84+0}{312·0.5} = 0.43$ min

<u>Semi-finish boring</u>:

$T_{m3}=\frac{1+1+65+1}{0.2·1250} = 0.26$ min

<u>Groove cutting:</u>

$T_{m4}=\frac{1+0+0+5}{0.2·315} = 0.095$ min

<u>Machine time for operation2:</u>

<u>Facing:</u>

$T_{2.1}=\frac{1+0+26+1}{160\cdot 0.63}=0.17$ min

Turning Ød2.2h14= Ø120h14($_{-0.87}$) on the length $A_{2.2}$ = 68H14($^{+0.74}$)

$T_{2.2}=\frac{1+0+68+1}{1\cdot 400}=0.28 mins$

<u>Machine time for drilling operation № 3</u> (Fig. 10.2):

Drilling 2 holes Ø5H12

$tg30°=\frac{2\cdot l_{eng}}{d}$; $l_{eng}=\frac{d\cdot tg30°}{2}=0.3d=1.8$

$l_{overtravel}$= 1 mm.

l_{app}=1

$T_{2.2}=\frac{1+1.8+15+0}{0.1\cdot 1100}=0.16 mins$

for 2 steps $0.16\cdot 2=0.32$ min

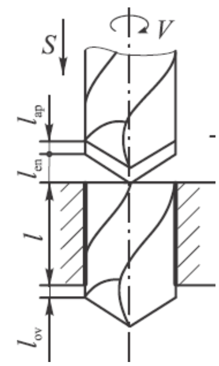


Fig.10.2. Diagrams for calculation of the estimated cutting distances during drilling [1]

<u>Machine time for operation 4:</u>

$T_{m\ 4.1}=\frac{1+1.8+25+0}{0.1\cdot 1100}=0.25$ min

<u>Machine time for operation 5</u>

$T_{m5.1}=\frac{1+1.8+15+0}{0.1\cdot 2000}=0.008$ min

Auxiliary time:

$T_{aux}=T_{m/d}+T_{c/u}+T_c+T_m$

where,

$T_{m/d}$=Time to mount and dismount

$T_{c/u}$=Time to clamp and Unclamp

T_c=Time for control

T_m=Time for measurement

Therefore,

T_{aux}=0.15+0.1+0.2+0.8=1.25 min.

<u>Operation time:</u>

Operation time can be calculated by the formula

$T_{op}=\sum_{i=0}^{n}(T_0 + T_{aux})$

Operation time for **operation1**:

T_{op1}=(0.058 +0.43 +0.26+0.095)+1.2=2.0 min

$T_{rest}=2.0\cdot 0.03 = 0.06$ min.

$T_{mount}= 2.0 \cdot 0.1 = 0.2$ min.

T_{0c}=2.0+0.06+0.2=2.26 min.

Standard time for operation 1

$H_t=\frac{T_S}{n} + T_{oc} = 2.26 + \frac{8}{200} = 2.3$ min

Operation time for operation2:

T_{0p2}=(0.32)+1.2=1.64 min.

$T_{rest}=1.64 \cdot 0.03 = 0.049$ min.

$T_{maint}= 1.64 \cdot 0.1 = 0.164$ min.

T_{0c}=1.64+0.049+0.164=1.85 min.

Standard time for operation 2

$H_t=\frac{T_S}{n} + T_{oc} = 1.85 + \frac{8}{200} = 1.89$ min.

Standard time for operation3:

T_{0p3}=(0.32)+1.2=1.52 min.

$T_{rest}=1.52\cdot 0.03 = 0.04$ min.

$T_{maint} = 1.52 \cdot 0.1 = 0.152$ min.

T_{0c}=1.52+0.04+0.152=1.7 min.

Standard time for operation 3

$H_t=\frac{T_S}{n} + T_{oc} = 1.7 + \frac{8}{200} = 1.74$ min.

Operation time for operation4:

T_{0p4}=(0.25)+1.2=1.45 min.

T_{rest}=1.45$\cdot 0.03 = 0.04$ min.

$T_{maint}$$= 1.45 \cdot 0.1 = 0.145$ min.

T_{0c}=1.45+0.043+0.145=1.63 min.

Standard time for operation 4

H_t=$\frac{T_s}{n} + T_{oc} = 1.63 + \frac{8}{200} = 1.67$ min.

Operation time for operation 5:

T_{0p5}=(0.08)+1.2=1.208mins

T_{rest}=1.20$\cdot 0.03 = 0.036$

$T_{maint}$$= 1.20 \cdot 0.1 = 0.120$

T_{0c}=1.20+0.036+0.120=1.36

Standard time for operation 5

H_t=$\frac{T_s}{n} + T_{oc} = 1.36 + \frac{8}{200} = 1.74$ min.

Conclusion

The manufacturing part of this project is been completed, with the help of software that helps in the design of the part to be manufactured and then the route of manufacturing process along with dimensional diagrams and complex graph tree which really contributed in making the complex part easy for the manufacturer to understand each operation and processing step in manufacturing and with tolerance analysis to ensure proper accuracy of the part been manufactured.

There after I calculated the manufacturing size of the part because initially the part is been die-forged /stamped and at this state we don’t know the exact size so I calculated the allowances, which is the volume of materials been removed in order to get the accurate manufacturing sizes, orderly the cutting parameters were also calculated which is very important in manufacturing.

Thereafter the standard time needed for production.

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2. Design of a fixture

Description

For designing a work-holding device for my part, I decided to design a cam flange mandrel with a pneumatic cylinder for turning operation.

The part is inserted on the cam flange mandrel and then the stoke of the cam flange mandrel is connected to the pneumatic cylinder stoke of a lathe 16K20 which is a turning lathe machine and then a pneumatic cylinder is connected to the back end of the spindle.

A bearing is attached to the pneumatic cylinder which prevents the rotation of the pneumatic cylinder.

Overall dimensions of the expansion mandrel

Diameter of the release repair: D=99.637 mm.

The following conditions must be satisfied:

$S_{max} \leq 0.2$ mm,

where S_{max} - is the largest gap between the surface of the work-piece hole and the surface of the expansion mandrel. S_{max}=0.2mm.

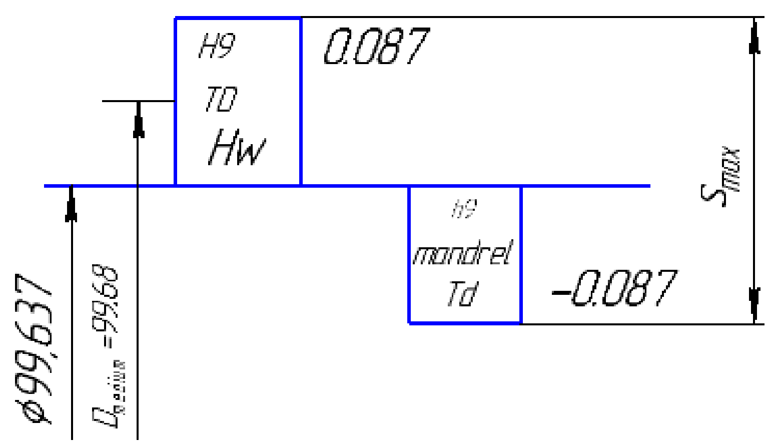


Fig. 2.1. Tolerance zones of the mandrel (Td) and the workpiece (TD)

Fit is the clearance fit between the mandrel and the part. For the self-centering mandrel maximal clearance have to be less 0.2 mm.

$S_{max}=T_D+t_d=0.087+0.087=0.174$ mm. $0.174\leq0.2$.

The condition is met. Assigning the overall dimensions of the cam flange mandrel according to GOST 17531-72 standards.

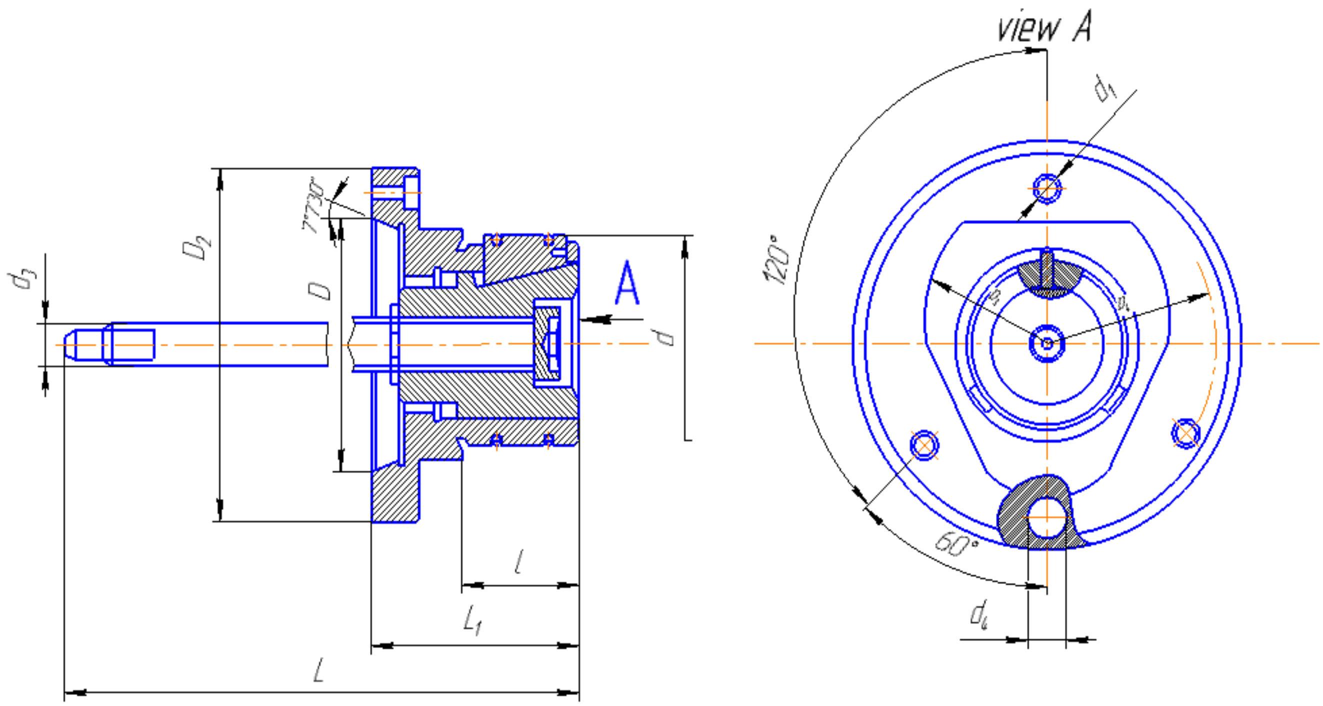


Fig. 2.2. Parameters of the mandrel

Table 2.1. Dimension of the cam flange mandrel

d	D		L	l	D_2	D_3	D_4	d_1	d_3	d_4	L_1	Weight, kg
	nominal	Deviations										
99.637	100	+0,004 -0,006	420	120	130	100	104,8 ±0, 2	16	M20	20.5 ±0,1	340	10.78

Calculation of the moments of cutting forces and friction

The subsequent cutting force will be carried out using the maximum force since in the operation, the outer part of the work-piece will be machined with the maximal tangential force $P_{z\,max}$

$P_{z\,max} = 2234.904$ N.

In machining of the part, the moment of cutting should be less than the moment of friction: $M_{CUT} \leq M_{fr}$.

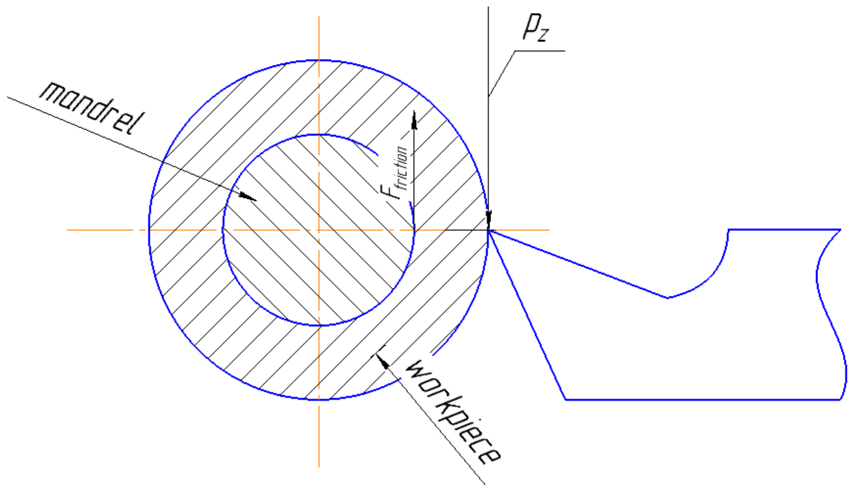


Fig. 2.3. Shem of forces, acting on the self-centering mandrel

The moment of cutting forces and friction can be calculated with the following formula

$$M_{cut} = P_z \cdot \frac{D_{med}}{2}$$

but,

$$d_{med} = \frac{d_{2.3}+d_{2.2}}{2} = \frac{129.5+119.5}{2} = 124.5\ [\text{mm}].$$

Therefore

$$M_{cut} = 2234 \cdot \frac{0.1245}{2} = 139\ [\text{N} \cdot \text{m}]$$

Moment of Friction can be calculated with the following formula

$M_{fric}=F_{fr} \cdot \frac{d_{mandrel}}{2}$

but the friction force is: $F_{fr}=N \cdot f$.

$N=P_Z \times \frac{d_{2.2}}{d_{Mandrel \cdot f}}$

where,

f - friction coefficient, f=0.15.

Calculation for support:

$N=2234 \cdot \frac{0.06}{0.05 \cdot 0.15} = 17872\ [N]$

Friction force can be calculated with the following formula

F=17872x0.15=2681 [N]

After the forces have been found, now we calculate the moment of friction by the following formula

$M_{friction}=2681 \cdot \frac{0.1}{2} = 134$ [N·m]

2.1. CALCULATION OF CLAMPING FORCE

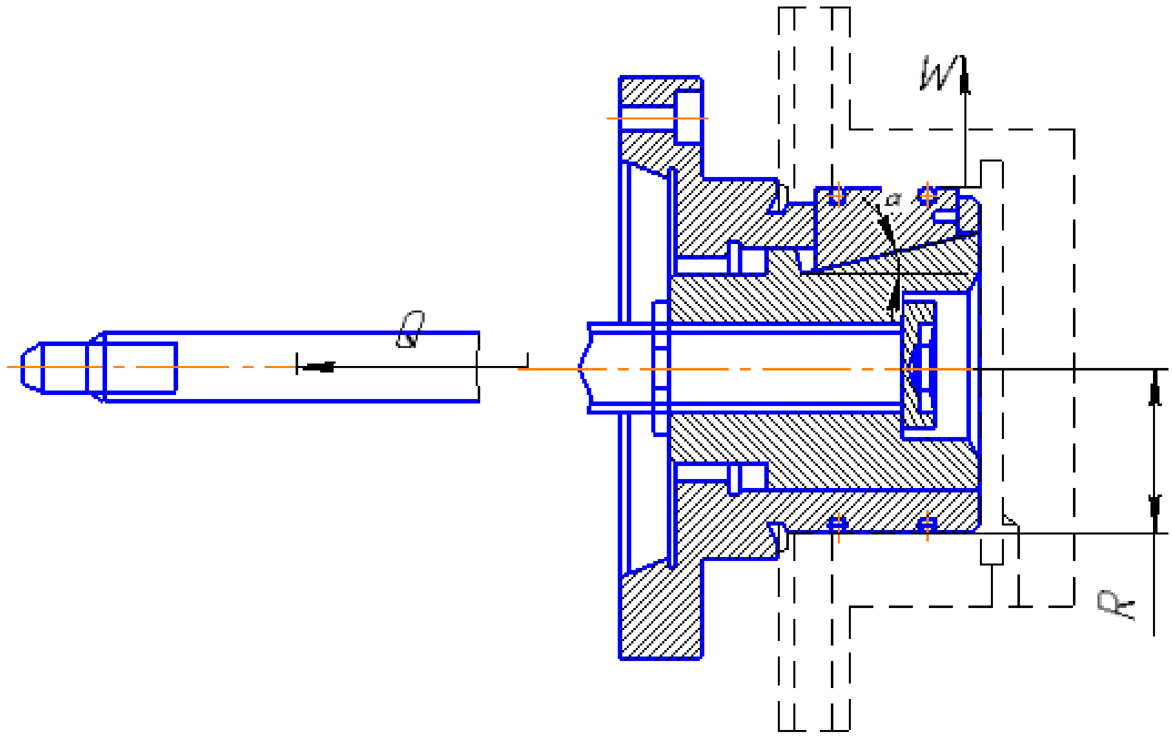


Fig. 2.4. Self-centering mandrel

$$W_{sum} \cdot f \cdot R = K \cdot M_{cut}$$

Therefore,

$$W_{sum} = \frac{M_{cut} \cdot K}{f \cdot R}$$

$$W = \frac{W_{sum}}{Z}$$

Where,

W_{sum}-The total clamping force by all cams

W-clamping force by one cam

Z-Number of cams

R-radius of the hole

$$R=\frac{D_{1.3}}{2}=\frac{100.0435}{2}=50mm$$

f - is the coefficient of friction f=0.15

K - is the coefficient of safety:

$K=K_0 \cdot K_1 \cdot K_2 \cdot K_3 \cdot K_4 \cdot K_5$

These coefficients are taken from [3, p.117]

Where,

K_0 =1.5 its guaranteed safety factor;

K_1=1.2 it takes into account the increase in cutting forces due to random irregularities of the workpiece surface when roughing ;

K_2=1 increase of cutting forces due to worn out tool

K_3=1 increase in cutting forces with intermittent cutting

K_4=1.3 coefficient that characterizes the force developed by clamping mechanism for mechanized drives

K_5=1 coefficient that characterizes the ergonomics of the non-mechanized clamping

Therefore,

K=2.34

we choose the accepted value for K

$K_{accepted}$=2,5

Therefore,

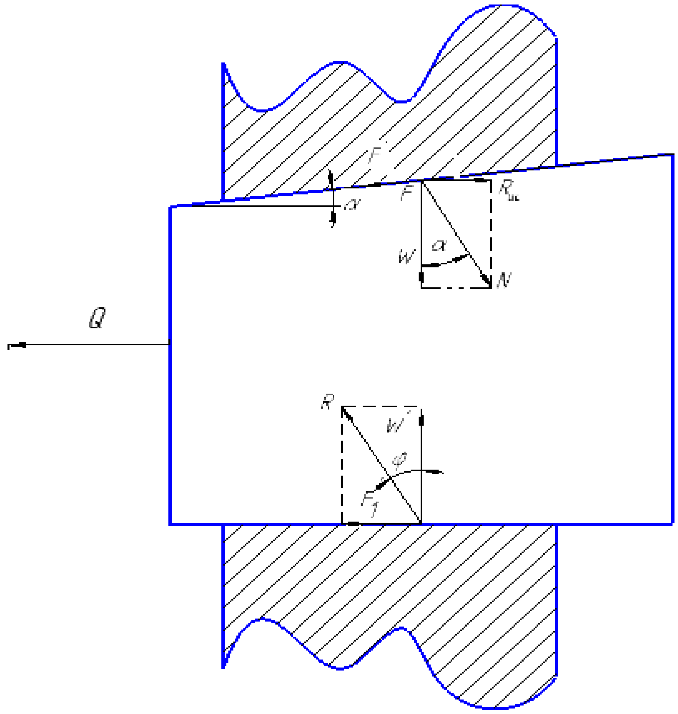
The total clamping force by all cams can be calculated with the following formula

$$W_{sum}=\frac{139 \cdot 2.5}{0.15 \cdot 0.05}=46.33\ [KN]$$

Then we find the clamping force per CAM:

$$W=\frac{46.33}{3}=15.44\ [KN]$$

Calculation of self breaking of the wedge



$F' + F_1 \geq R_{ac}$

Friction force of the wedge:

$$F = N \cdot f = W \frac{tg\varphi}{\cos\alpha}$$

We find the horizontal component of the frictional force by the formula:

$F' = W \cdot f$

The magnitude of the normal reaction on the basis of the wedge:

$W' = W \cdot (1 + tg\alpha \cdot tg\varphi)$

Frictional force on the basis of a wedge:

$F_1 = W' \cdot tg\alpha$

Reverse action force:

$R_{ac} = W \cdot tg\alpha$

Therefore,

The self-breaking condition of the wedge: $\alpha < 2\varphi$

Coefficient of safety of the self breaking wedge:

$$K = \frac{2tg\varphi}{tg\alpha}$$

Then we find the angle of slope of the wedge:

$$tg\alpha = \frac{2tg\varphi}{K} = \frac{2 \cdot 0.15}{2.5} = 0.12$$

$\alpha = arctg12 = 6.8 = 6°48'$

Therefore we obtain the strength of the reaction of the support by the formula:

$$F = W \cdot \frac{tg\varphi}{cos\alpha} = 15.44 \cdot \frac{0.15}{cos6°48'} = 2.33\ [KN]$$

Therefore we obtain the strength of the reaction of the support by the formula:

$$N = \frac{F}{f} = \frac{2.33}{0.15} = 15.53\ [KN]$$

Reverse action force can be calculated with the following formula:

$$R_{af} = W \cdot tg\alpha = 15.44 \cdot 0.12 = 1.85\ [KN]$$

The horizontal component of the friction force of the wedge:

$F' = W \cdot f = 15.44 \cdot 0.15 = 2.31$ [KN]

The value of the normal reaction on the basis of the wedge:

$W' = W \cdot (1 + tg\alpha \cdot tg\varphi) = 15.44 \cdot (1 + 0.12 \cdot 0.15) = 15.71\ [KN]$

Force of friction based on the wedge:

$F_1 = W' \cdot tg\varphi = 15.71 \cdot 0.15 = 2.35\ [KN]$

We check the equilibrium condition of the wedge by the formula:

$$F' + F_1 \geq R_{af}$$

$$2.31 + 2.35 \geq 1.85$$

$$4.66 \geq 1.85$$

The condition is met.

Checking the self-breaking condition of the wedge by the formula:

$$\alpha < 2 \cdot \varphi$$

$$6^{\circ}48' < 2 \cdot 8^{\circ}30'$$

$$6^{\circ}48' < 17^{\circ}$$

The condition is met.

The force of the air drive is calculated by the formula:

$$Q = W_{sum}(\tan\alpha + 2\tan\varphi)$$

$$Q_{stem} = 46.33(0.12+2*0.15) = 19.458 \text{ KN} \quad (14)$$

$$Q_{piston} = \frac{\pi \, D2}{4} \cdot P = \frac{3.14*(0.25)2}{4} 0.4 = 19635 \text{ N} = 19.63 \text{ KN}$$

Where D – is diameter of a piston (we accepted D=250 mm from the handbook).

P is the pressure of the air set:

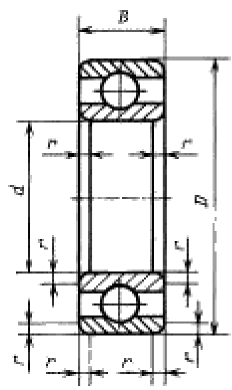
$P = 0.4$ [MPa] =0.4 [N/mm^2] = $0.4 \cdot 10^6$ [N/m^2]; D=250mm (diameter of the cylinder)

Hence,

$$Q_{piston} > Q_{stem}$$

Bearings

The bearing can withstand the force Q_{piston}=19635 N: $C_0 > Q_{piston}$



Bearing designation	d	D	B	r	C, N	C_0, N
403	17	62	17	2.0	100000	630000

Q_{piston}=19635 N **< C_0 =63000 N – condition is met.**

3. Machine shop design

3.1. Initial data and calculation of labor input for machining all parts in the shop

The main aim is to calculate the area installing the machines needed for manufacturing processes, time of machining, number of workers, number of machines to be used. It is necessary take into account manufacturing process of complex part.

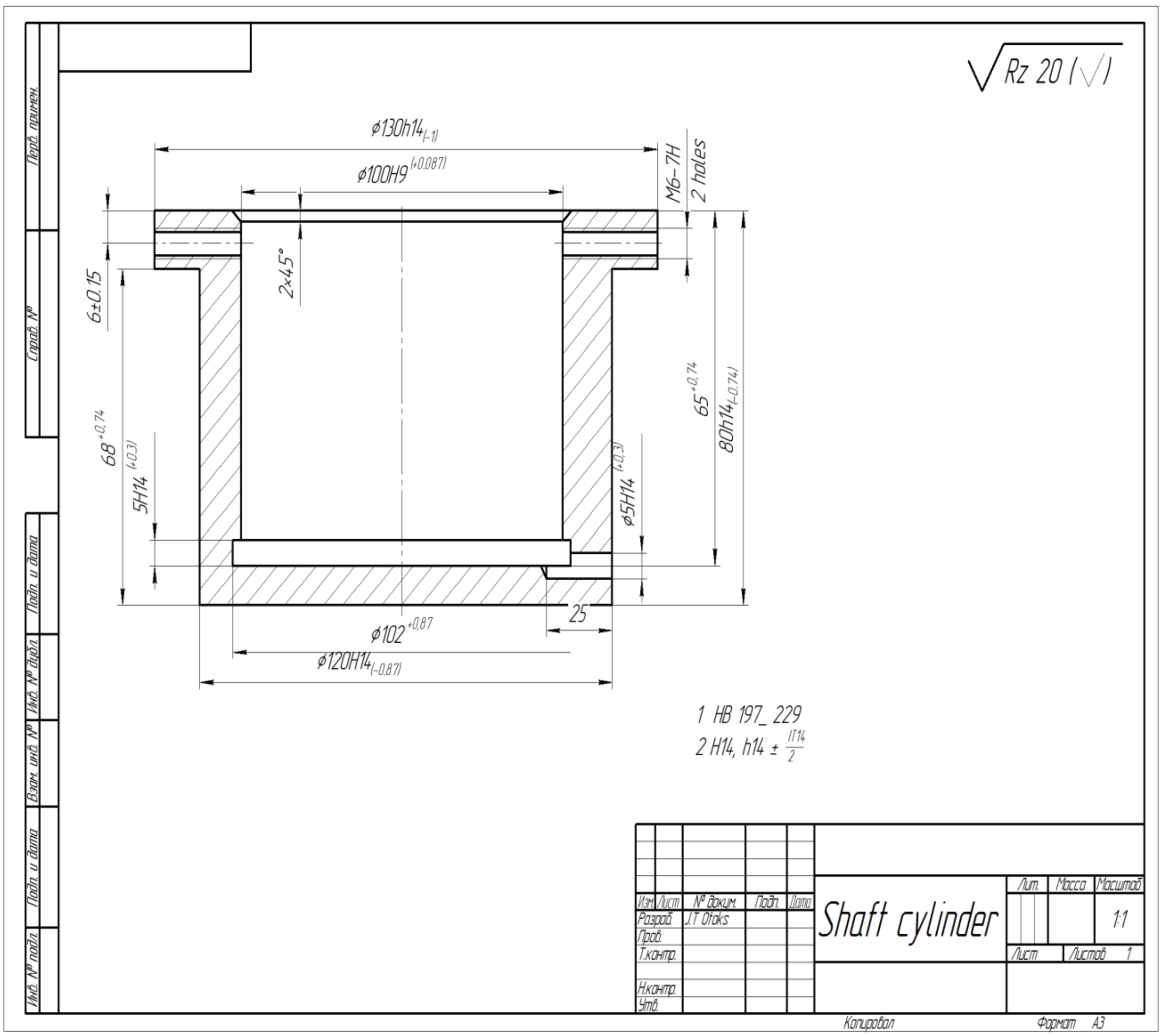


Table 3.1. Content of manufacturing process of complex part “Flange”

No. of Operation	Name of Operation	Standard time Hs, min	Model of Machine	Size of the Machine(LxWxH)
000	Die Forging	2.2		
010	Turning	6.82	16K20	3700x2260x1650
015	Turning	4.51	16K20	3700x2260x1650
020	drilling	1.3	2M112	2210x1020x1350
025	drilling	0.1	2M112	2210x1020x1350
	Total	12.37		

Calculation of labor input of the annual program for machining all parts of constructive-technological similarity group in a small-scale manufacture

1. Calculate reduction factors for all parts of the considered group, write down the results of calculation in Table 4;
2. Labor input is determined through *the reduction coefficient* calculated for each part,

$$\mathrm{T}_i = \mathrm{T}_{\mathrm{repr.}} \times \mathrm{K}_{\mathrm{red}_i}, \qquad (3.1)$$

where T_i – labor input of machining the considered part in the designed shop; $\mathrm{T}_{\mathrm{repr.}}$ –labor input of machining the part-representative (the complex part) in the designed shop; $\mathrm{K}_{\mathrm{red}.i}$ – *the reduction coefficient* of the considered *i* part.

The reduction coefficient is determined in accordance with the formula

$$\mathrm{K}_{\mathrm{red}_i} = \mathrm{K}_{\mathrm{w}_i} \times \mathrm{K}_{\mathrm{s}_i} \times \mathrm{K}_{\mathrm{c}_i} \times \mathrm{K}_{\mathrm{m}_i}, \qquad (3.2)$$

where: $\mathrm{K}_{\mathrm{w}\,i}$ – the reduction coefficient of weight (it would be more correct to use the reduction coefficient of the processed area of the part, but it correlates with the weight of the part which is written in the part drawing); $\mathrm{K}_{\mathrm{s}\,i}$ – the reduction coefficient of seriality (the more the production program, the more possibility of applying special attachments which reduce time for part installation); $\mathrm{K}_{\mathrm{c}.i}$ – the reduction coefficient of complexity; $\mathrm{K}_{\mathrm{m}.i}$ – the coefficient considering the influence of the process material type on the cutting mode.

There can be a lot of such coefficients (for example, coefficients considering a blank surface condition, application of cutting fluids and etc.), but the first three factors are usually applied. They are determined as follows:

$$\mathrm{K}_{\mathrm{w}_i} = \sqrt[3]{\frac{W_i^{\,2}}{W_{\mathrm{rep}}^{\;2}}}\,, \tag{3.3}$$

where: W_i – weight of the considered i part; W_{rep} – weight of the part-representative.

The *reduction coefficient of seriality* is determined depending on the ratio of the annual production program of the part-representative to the annual production program of the considered i part (N_{rep}/N_i):

$$\mathrm{K}_{\mathrm{s\,i}} = (N_{\mathrm{rep}} / N_i)^{\alpha}\,, \tag{3.4}$$

where: α – power exponent; α=0,15 for factories of light and medium machine building; α=0,2 for factories of heavy machine building. It is possible to apply the following coefficients for medium machine building:

if $N_{rep}/N_i \le 0.5$, the $K_s = 0.97$;

if $N_{rep}/N_i = 1.0$, the $K_s = 1.0$;

if $N_{rep}/N_i = 2.0$, the $K_s = 1.12$;

if $N_{rep}/N_i = 4.0$, the $K_s = 1.22$;

if $N_{rep}/N_i = 8.0$, the $K_s = 1.28$;

if $N_{rep}/N_i = 2.0$, the $K_s = 1.12$;

if $N_{rep}/N_i \ge 10$, the $K_s = 1.37$.

The *reduction coefficient of complexity* (K_s) allows for the influence of workability of industrial product on machining content of processing or labour intensity of assembling. In general, it is possible to represent the reduction coefficient of complexity (K_s) in the form of a coefficient product considering the dependence of labor intensity of the considered article and features of its design. For homogeneous parts of the group the most essential parameters are accuracy and surface roughness of the part:

$$K_c = \frac{K_{a\_i} \times K_{r\_i}}{K_{a\_rep} \times K_{r\_rep}}. \quad (3.5)$$

Accuracy and roughness factors of the *i* part (K_{a_i}, K_{r_i}) and the representative (complex) part (K_{a_rep}, K_{r_rep}) are determined by Table 3.2 and 3.3. Average accuracy (average accuracy degree) is defined as the sum of accuracy degree numbers of all sizes of the part divided by the quantity of the considered sizes. The average roughness is defined in the same way.

Table 3.2. Accuracy factors (K_{a_i}, K_{a_rep})

Average grade of tolerance	6	7	8	11	12	13
K_{a_i} or K_{a_rep}	1.3	1.2	1.1	1.0	0.9	0.8

Table 3.3. Roughness factors (K_{r_i}, K_{r_rep})

Average roughness, *Ra*, a micron	20	10	5	2,5	1,25	0,63
K_{r_i} or K_{r_rep}	0.95	0.97	1.0	1.1	1.2	1.4

- After determining the reduction coefficient for each part labor intensity of the annual program is calculated for each part in the group: $T_{Ni} = T_i \times N_i$. Labor intensity of machining the annual program of all parts in the group is calculated as the sum of labor intensity of the annual program for each part: $T_{\sum Ni} = \sum T_{Ni}$.
- Labor intensity for other groups of parts is calculated in the same way as mentioned above.
- Total labor intensity of all parts machined in the designed shop is calculated in this way: $T_{gen.} = \sum T_{\sum Ni}$.

If each group of parts is machined only at a separate site in the shop, the further calculation of the amount of machine tools at each site is carried out according to labour intensity of the annual program of all parts only in this group $T_{\sum Ni}$. If the parts of all groups are machined at sites irrespective of a certain group, the further calculation of the amount of machine tools is carried out according to the total labor intensity of all parts $T_{gen..}$

Notice: part № 0 is the complex part and it is not required to calculate labor input of the annual program to process this part.

Table 3.4. labor input of the annual program for machining all parts of constructive-technological similarity group

№ of part	Weight of part, kg	Reduction factor on weight, $K_{w\,j}$	Annual production program, N_j, pieces	Reduction factor on seriality, $K_{s\,j}$	Average grade of tolerance and accuracy factor $K_{a\,j}$	Average surface roughness, Ra, microns, and roughness factor $K_{Ra\,j}$	Reduction factor on complexity, $K_{c\,j}$	Total reduction factor, $K_{r\,j}$	Labour input of manufacturing one part j, $T_{c.f.\,j}$, minutes	Labour input of annual program for manufacturing part j, $T_{N\ c.f.\,j}$, minutes
1	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***
0	11.84	1	11000	1	12→0.9	20→ 0.95	0.85	0.85	**12.73**	----
1	10.84	0.93	10000	1	11→1.0	10→ 0.97	1.14	**1.06**	13.49	1248.3
2	7	1.13	12000	1.1	8→1.1	5→ 1	1.12	1.39	18.75	1750
3	5	1.18	14000	1.3	13→0.8	10→ 0.97	0.71	0.200	3.75	875
4	4	0.79	10000	1.2	7→1.2	2.5→ 1.1	1.68	1.72	6.45	720
5	3	0.86	9000	0.91	12→0.9	20→ 0.95	0.64	0.66	4.25	875
6	2.8	0.82	10000	1.0	8→1.1	5→1.0	1.28	0.94	3.995	665
7	1.2	0.96	12000	1.0	8→1.1	5→1.0	1.28	1.22	4.87	974
8	0.85	0.57	15000	1.0	13→0.8	10→0.97	0.71	0.40	1.94	485
9	0.5	0.77	16000	1	13→0.8	10→ 0.97	0.71	0.54	1.04	277
10										
						za	**Total:** $T_{\Sigma N\ c.f.\,.} = \Sigma T_{N\ c.f.\ 2}$			**42590 hrs.**

In our example we suppose that processing of parts of other groups will be carried out in other shops

$T_{gen.} = \sum T_{\sum Ni}$. = 42590 hrs (see Table 4)

3.2. Calculation of the required amount of equipment and workplaces

The amount of machine tools of j-type is calculated:

$$C_{c\,j} = T_{N\,c\,m\text{-}t\,j.} / F_{r\,m}, \qquad (3.6)$$

1. **For the single-piece and small-scale production** calculation is done according to the part-representative or complex part:

- Labor input of machining the *part-representative* for the given machining tool is calculated for each *j type* of the machine tool $t_{c\,f\,j}$, minute;
- The operating ratio of the given type of the equipment is determined

$$\alpha_j = \sum t_{c\,f\,j} / T_{c\,f}\,, \qquad (3.7)$$

where $T_{c\,f}$ is total labor input of machining one part-representative

- The total number of machine tools is calculated

$$C_c = T_{\Sigma N\,c} / F_{r\,m}, \qquad (3.8)$$

where $T_{\Sigma N\,c}$ is total labour input for machining all parts of the annual program in the group, hrs; $F_{r\,m}$ is the actual annual time arrangement of using the equipment according to the corresponding amount of shifts *m* a day, hrs.

- The amount of machine tools of each *j* type is calculated

$$C_{c\,m\text{-}t\,j} = C_c \times \alpha_j. \qquad (3.9)$$

- The accepted amount of machine tools of each type of $C_{ac\,m\text{-}t\,j}$ of the machine tool is determined taking into account the admissible overtime of 10 %.

- The total accepted amount of machine tools is calculated as the sum of the accepted amount of machine tools of each *j* type

$$C_{ac\ m\text{-}t} = \Sigma C_{ac\ m\text{-}t\ j}\ . \qquad (3.10)$$

The detailed calculation of labor input according to the reduced program is considered before in section “Raw data for shop design”.

2. Total quantity of machine tools is calculated in accordance with the formula:

$C_c = T_{\Sigma N\ c.f.\ j} / F_{r\ m} = 42590/4030 = 11.0$ piece.

where $T_{\Sigma N\ c.f.\ j}$ – labor input of the annual program for machining all parts in the group of constructive-technological similarity; $F_{r\ m}$ – the actual annual time arrangement of the equipment used at double-shift working.

Table 3.5. Calculation of labor input for small-scale manufacture

No.	Name of operation	Model of Machine tool	Summing-up calculated floor-to-floor time $t_{c\ f}$ of operations using the same model of the machine tool $\Sigma t_{c\ f\ j}$, minutes
1, 2	Turning	16K20	6.82+4.51=11.33
3, 4	Drilling	2M112	1.3+0.1 = 1.4
			Total =12.73 min

1. Calculate the level of equipment use $\alpha_{m\text{-}t}$ for each model of the machine tool;
   $\alpha_{k1620} = \Sigma t_{c\ f\ 16k20} / T_{c.f.\ complex} = 6.28+4.51/12.73 = 0.84;$

   $\alpha_{2m112} = \Sigma t_{c\ 2m112} / T_{c.f.\ complex} = 1.3+0.1/12.37 = 0.11;$

2. We calculate the quantity of each machine tool model $C_{c\ m\text{-}t}$ in accordance with the formula (9) and fix the accepted machine tools quantity $C_{ac\ m\text{-}t}$:

$$C_{16K20} = C_c \times \alpha_{16K20} = 11.56 \times 0.84 = 8.8 \approx \mathbf{9} \text{ pieces;}$$

$$C_{2M112} = C_c \times \alpha_{2M112} = 10.56 \times 0.11 = 2.0 \approx \mathbf{2} \text{ pieces.}$$

5. The total quantity of accepted machine tools is calculated:

$C_{ac\,\Sigma} = \Sigma C_{ac\ m\text{-}t} = 9 + 2 = 11$ pieces.

3.4. Calculate the required area

The total production floor space

$$S_m = \sum_{i=1}^{n} C_{ac.i} \times f_i \ , \qquad (3.11)$$

where S_m – the total production floor space, m^2; $C_{ac\,i}$ – the given amount of machine tools of the given model or type; n – a number of models or types of machine tools used in the production work; f_i – a specific production floor space, m^2/machine tool.

The specific production area depends on a particular model of the machine tool. For integrated calculations the following data is used:

For small machine tools f = 7-10 m^2/machine tool;

For medium machine tools f = 10-20 m^2/machine tool;

For large machine tools f = 20-60 m^2/machine tool;

$$S_m = C_{ac\ tot} \times f = 11 \times 20 = 220 \text{ m}^2.$$

$$S_{total} = S_m \times k_{aux} = S_m \times 2 = 220 \times 2 = 440 \text{m}^2.$$

3.5. Calculation method for employment size

To calculate the employment size various methods are used.

1. ***Calculation of direct labour*.**

- *According to work labour input:*

$$R = T / (F_{r\,w} \times K_m), \qquad (3.12)$$

$$R = 42590 / (4015 \times 1) = 11.0$$

$$R_{accepted} = 11 \text{ workers}$$

where R – amount of workers; T – labor input of the corresponding aspect of operations (turning, milling and etc.); $F_{r\,w}$ – the actual time arrangement of workers; K_m

– the factor of multi-machine service (it is applied only for multi-machine service). For integrated calculations K_m=1.1–1.35 for small-scale manufacture; K_m=1.3–1.5 for medium-size manufacture; K_m=1.9–2.2 for mass production.

6. *Calculation of required helpers*

$$R_{helpers}=25\ \%\ \text{of}\ R_{accepted}$$
$$R_{helpers}=0.25\times 11=2.75$$
$$R_{helper(accepted)}=3\ \text{people.}$$

3.6. REFERANCES

1. Kozlov V.N., Pichugova I.L. Machine shops design: study aid / V.N. Kozlov, I.L. Pichugova; Tomsk Polytechnic University. – Tomsk: TPU Publishing House, 2012. – 132 p.

4. ASSIGNMENT FOR THE SECTION

‹‹FINANCIAL MANAGEMENT, RESOURCE EFFICIENCY AND RESOURCE-SAVING »

Student:

Group	Surname, First name
8Л4И	Otokuefor Jerome Tseyi

School	The School of Advanced Manufacturing Technology (ScAMT)
Major	15.03.01 “Mechanical engineering”
Division of School	Division for Materials Science (DMS)

The initial data to the section "Financial management, resource efficiency and resource-saving" :	
1. The cost of resources for the manufacture of parts "Flange"	1. The cost of basic materials determine on the basis of price lists organizations-sellers of materials 2. Hourly tariff rates by categories works: 1st class - 40 rubles per hour. 2ndclass - 51 rubles per hour. 3rd class - 65 rubles per hour. 4th class - 82.96 rubles per hour. 5th class - 105.81 rubles per hour. 6th class - 135 rubles per hour. The work orders should be determined on the basis of the Unified tariff-qualification guide, section "Mechanical treatment of metals and other materials » 3. Tariff for electricity - 5.8 rubles / kWh.
2. Norms of expenditure of resources	To calculate the following limits norms of resource consumption: -cost of transport-procuring expenses - 0.06 -costs on the maintenance of workers maintenance of machinery and equipment, not directly occupied by manufacture products - 40% of the total salary and deductions from its main workers costs for materials used for operation of the equipment, it is

	- 20% of depreciation -costs for repair of equipment -100-120% of basic salary of the main workers. - general workshop costs - 50 - 80%, from the main salaries of basic workers - general business expenses -50% of the main salaries of the main workers. -expenditures for sale - 1% of production cost
3. The used taxation system, rates taxes, deductions, discounting and lending	The rate of deductions for social needs - 30% of wage fund The rate of deductions to the social fund accident insurance for production - 0.7% of wage fund Value Added Tax - 18% from product prices.
List of issues to be investigated, designed and developed:	
1. Calculation of the cost of manufacturing parts "Flange"	1. To carry out calculation of expenses for main and auxiliary materials (after deduction return waste) 2.Take the calculation of costs for the main and additional salaries of basic production workers, deductions for social needs. 3. To carry out the calculation of the cost of maintenance and operation of equipment. 4. Carry out a calculation of the value of general shop, general economic, non-productive costs. 5. To conduct calculation of the cost price.
2. Calculation of the price of the "Conical shaft" part with VAT	Calculation is done using normative method of pricing. The norm profitability should be within 5-20%

The assignment was issued by:

Post	Name	Scientific degree, a rank	Signature	Date
Senior Lecturer	Potekhina N.V.			

The assignment was executed by the student:

Group	Surname, First name	Signature	Date
8Л4И	Otokuefor Jerome Tseyi		

4. FINANCIAL MANAGEMENT, RESOURCE EFFICIENCY AND RESOURCE-SAVING

Introduction

The purpose for this part, is to calculate the cost of the products, which is manufactured according to the manufacturing process in some standard conditions for production.

Calculation of costs under the item <<Raw materials and materials>>

The article includes the cost of the main materials that are directly included in the manufactured product (parts), as well as the auxiliary materials used for technological purposes. The cost of materials is determined by the norms of their consumption and purchase prices, taking into account mark-ups and extra charges per unit of material in physical terms. Transportation and procuring costs are added to the cost of raw materials, materials, as well as purchased products, semi-finished products and fuel.

The Rate of Consumption of Material,

$N_{OTX} = \frac{200}{7000} = 0.028[Kg]$

Cost of material per one piece amounts to:

$C_{mo} = w_i \cdot p_i \cdot (1 + K_{TZ})$

$C_{mo} = 11.84 \cdot 52 \cdot (1 + 0.06) = 652 RUB$

where,

W-Mass of the workpiece; p-price of material per one kg for all stamped materials.

K-is the coefficient of transportation and procurement cost $K_{TZ}=0.06$

Auxiliary materials will take 15% of the total material cost.

$C_{мв} = C_{MO} \cdot 0.15 = 97.8 RUB$

Transportation and procurement expenses will take 15% of the material cost

$C_{TZ} = 652 \cdot 0.15 = 97.8 RUB$

The total cost in this article is equal to the summation of

$C_M = C_{MO} + C_{CB} + C_{TZ} = 652 + 97.8 + 97.8 = 847.6 RUB$

Calculation of cost under <<purchased products and semi-finished products>>

The article doesn’t apply due to the fact that the manufacturing process doesn’t provide the purchase of semi-finished products.

Calculation of under the item << Returnable products and semi-finished products>>

This calculation encompasses the cost of waste. This value is excluded from the cost of production.

The calculation is carried out by the formula;

$$C_{OT} = M_{OT} \cdot P_{OT} = (B_{\text{ЧР}} - B_{\text{ЧСТ}}) \cdot (1 - \beta) \cdot P_{OT},$$

Where,

M_{OT}-Quantity of waste obtained in the manufacture of a unit of production

$P_{OT} - ispriceofthewaste, \frac{rub}{ton}(7533);$

$B_{\text{ЧР}} - Massofthework - piece\ 11.84kg$

$B_{\text{ЧСТ}} - Netweightofthepart$8.5kg

$\beta - Fractionofirretrievablelosses\ (0.02)$

Therefore,

$$C_{OT} = (11.84 - 8.5) \cdot (1 - 0.02) \cdot 7.5 = 19.57\text{RUB}$$

Calculation of cost for fuel and energy for manufacturing purposes

These type of calculations are absent

Calculation of costs under Basic wages of industrial workers

This calculation includes the cost of labour for workers directly proportional to the products manufacture.

Calculations are made using the formula;

$$C_{OZП} = \sum_{I=1}^{K_O} \frac{T_i^{шт.к}}{60} \cdot чтс_i \cdot K_{np,}$$

Where, $T_i^{шт.к}$- unit time of the per operation, min;

K_0 - the number of operations in the process;

ЧТСi -is the passable tariff line for the per operation;

Kpr - coefficient taking into account additional payments, payments and bonuses provided for by the labor legislation. When designing, you should take it equal to 1.4

$C_{озп1}= \frac{t_i^{шт.к}}{60} \cdot чтс_i \cdot K_{np} = \frac{6.8}{60} \cdot 135 \cdot 1.4 = 21.42$rub

$C_{озп2}= \frac{t_i^{шт.к}}{60} \cdot чтс_i \cdot K_{np} = \frac{4.51}{60} \cdot 135 \cdot 1.4 = 14.17$rub

$C_{озп3}= \frac{t_i^{шт.к}}{60} \cdot чтс_i \cdot K_{np} = \frac{1.31}{60} \cdot 65.05 \cdot 1.4 = 1.82$rub

$C_{озп4}\frac{t_i^{шт.к}}{60} \cdot чтс_i \cdot K_{np} = \frac{0.1}{60} \cdot 40 \cdot 1.4 = 0.09$rub

Total basic salary:

$$C_{OЗП} = \sum_{I=1}^{K_O} \frac{T_i^{шт.к}}{60} \cdot чтс_i \cdot K_{np} = 37.5\ rub$$

Calculation of items under additional wages of production workers

This calculation takes into account the payment provided by labour provided for the time not used in production: additional and educational leave, medical situations.

Calculation of additional wages is calculated with the formula

$$C_{ДЗП} = C_{OЗП} \cdot K_{Д}$$

Where,

$C_{OЗП} - Isthebasicsalaryinrubles$

$K_{Д} - Thefactorconsideringadditionalsalary$

When designing, it should be taken as 0.1

$$C_{ДЗП} = C_{OЗП} \cdot K_{Д} = 37.5 \cdot 0.1 = 3{,}750 rub$$

Calculation of cost under Taxes, deductions to the budget and extra-budgetary funds

This includes contributions to the statutory fund in the pension fund, social security fund, compulsory health insurance, and other social needs,

Calculation of cost under Taxes, deductions to the budget and extra-budgetary funds can be done using the formula

$$C_H = (C_{ОПЗ} + C_{ДЗП}) \cdot \frac{(C_{CH} + C_{CTP})}{100}$$

$C_{ОЗП} - Isthebasicsalaryinrubles$

$K_{Д} - Thefactorconsideringadditional\ salary$

$C_{CH} -$ The social tax rate (accepted 30%);

$C_{CTP} -$ The rate of insurance premiums for other types of compulsory insurance (accepted 0.7%);

$$C_H = \frac{(37.5 + 3{,}750) \cdot (30 + 0.7)}{100} = 11.62 rub$$

Calculation of costs under the item "Expenses for the maintenance and operation of machinery and equipment"

This article is comprehensive and includes the following types of costs:

- depreciation of equipment and valuable instrument (tooling), designation C_a;
- Operation of equipment (except repair costs);
- Repair of equipment;
- Intra-factory movement of goods;
- repayment of the cost of general purpose tools and devices;
- Other expenses.

Element "a" Depreciation of equipment is determined on the basis of depreciation rates and book value of the relevant equipment, the following formula is used to calculate its annual value.

$$A_{год} = \sum_{i=1}^{T} Ф_i \cdot H_{ai} + \sum_{j}^{m} Ф_j \cdot H_{ai}$$

Where

$Ф_i$- initial (balance) cost of a unit of equipment of the i-th type, i = 1, ..., T;

T is the number of types of equipment used;

$Ф_j$ is the same for the j-th type of tooling j = 1, ..., m;

m - The number of types of equipment used;

$H_{обi}$ and H_{ochj} - The corresponding depreciation rates.

Ф- (lathe) = 2,600,000 rub. (2 pieces)

Ф-Drilling = 267093 руб.

The depreciation rate in general form is determined by the formula

$$H_a = \frac{1}{T_{mu}}$$

Where,

$T_{mu} - its\ the\ time\ of\ important\ use\ taken\ from\ table 4$[9]

Turning machine 16k20=

Vertical drilling machine 2m112: $\text{н}_a = \frac{1}{T_{ТИ}} = \frac{1}{10} = 0.1$

$A_{MAX} = 260000 \cdot 2 = 52000{,}0 RUB$

$A_{DRILL} = 267093 \cdot 0.1 = 26709{,}3 RUB$

$A_{Anual.all} = 52000{,}0 + 26709{,}3 = 78709.3$

The expected average utilization of the equipment used is determined using the formula

$$l_{кр} = \frac{N_B \cdot \sum_{i=1}^{P} t_i^{шт.к}}{\sum_{i=1}^{P} F_i}$$

Where N_B is the annual output of the product (parts);

P - number of operations in the Manufacturing process;

$t_i^{штк}$ – the unit-calculation time for the i-th operation of the process, i = 1, .., P; Fi is a valid annual fund of the operating time of the equipment used at the i-th operation, taking into consideration the number of shifts taken.

For metal cutting machines of 1-30 categories of repair complexity with a two-shift operation mode Fi = 4015 hours, with a higher complexity - 3904 hours.

$$l_{кр} = \frac{7000 \cdot 12.71}{60} / 5 \cdot 4015 = 0.07$$

$$C_a = \left(\frac{A_{год}}{N_B}\right) \cdot \left(\frac{l_{кр}}{\eta_{з.н}}\right) = \left(\frac{787093}{7000}\right) \cdot \left(\frac{0.06}{0.8}\right) = 8.4 \text{rub}$$

Where,

$\boldsymbol{\eta_{з.н}}$ – is the normative coefficient of equipment loading. varying on the type of production the values should be taken :mass and large-scale - 0,7; medium-scale - 0,8; small-scale - 0,85.

Element <<b>> equipment operation includes:

The full maintenance cost of workers engaged in servicing machines and equipments not directly engaged in manufacturing products; the amount estimated is 40% of the full salary and deductions of the salary from the main workers engaged in the manufacture of the product.

$$C_{экз} = \left(C_{ОПЗ} + C_{ДЗП} + C_{Н}\right) \cdot 0.4 = (37.5 + 3.750 + 11.62) \cdot 0.4 = 21.14RUB$$

Cost of materials spent for work, equipment is taken to be 20% of the amount been depreciated. That is;

$$C_{МЭКС} = 8.4 \cdot 0.2 = 1.68$$

In the bachelor’s thesis, only energy cost taking into consideration according to the formula;

$$C_{ЭЛ.П} = Ц_{Э} \cdot K_{П} \cdot \sum_{i=1}^{P} W_i \cdot K_{Mi} \cdot t_i^{machine}$$

Where,

$Ц_{Э} -$ for electricity measured in kilowatts

$K_{П} -$ The coefficeint for power loss (1.05);

$W_i -$ power of the electric drive

$K_{Mi} -$ coefficient of utilization by capacity usually from $0.6 - 0.7$

$$Ц_{Э} - 5.8rub$$

$$C_{ЭЛ.П} = 5.8 \cdot 1.05 \cdot (0.3 + 0.2 + 0.03 + 0.5 + 0.06 + 0.05) \cdot 0.6 = 4.1rub$$

Repair of Equipments;

Repair of equipments deal with the cost of parts that have been damaged due to some certain reasons.

They are determined to be enlarged on the basis of the standard of expenditure - 100% of the basic salary of the main production workers, i.e.

Repair of equipment scan be calculated with the following formula;

$$C_{рем} = C_{озп} \cdot 1{,}0 = 37.5 \cdot 1{,}0 = 37.5\, руб.$$

Element<<d>>cargo transportation; Encompasses the cost of maintenance of vehicles or trucks or other cargo means: the cost of spare parts, fuel and payments of transport workers and third party organizations. But when performing bachelor’s thesis, the cost are allowed to be ignored.

Re-payment of the cost of tools; Includes all categories of manufacturing equipment with a life span for less than one year.

Calculation of the cost of tools can be carried out by the formula;

$$C_{ИОН} = \frac{(1 + K_{ТЗ}) \cdot \sum_{i=1}^{P} Ц_{Иi} \cdot t_{Рез.i} \cdot m_i}{T_{СТ.И.i} \cdot n_i}$$

Where$Ц_{Иi}$ is the price of the instrument used at the 1st operation,

$t_{Рез.i}$- Time of the tool used in the operation, min;

m_i - number of simultaneously used tools, (mi = 1);

$T_{СТ.И.i}$- Period of tool life (cutting time between the brushes), min;

n_i - possible number of rewinds of the tool, for bent incisors 4;

$K_{ТЗ}$- Coefficient of transport-procuring expenses ($K_{ТЗ}$ = 0,06).

table1

This table includes the name of the instruments for cutting and the time for cutting, the tool-life and their prices in (rubles).

Name of equipment	Time	Tool-life	Price (rubles)	$(\frac{\sum_{i=1}^{P} Ц_{Иi} \cdot t_{Рез.i} \cdot m_i}{T_{СТ.И.i} \cdot n_i}$
Cutter (T15k6)	O.15	30	4980	6.225
Boring tool (T15K6)	0.1	30	3500	2.91

Drilling tool (P6M5)	0.32	30	600	1.6

$$C_{ИОН} = (1 + 0.06) \cdot (62.25 + 2.91 + 1.6) = 113RUB$$

For manufacturing equipment with life span more than a year

Name	Price in rubles	Life span	Expenses per Year (rubles
Cam flange mandrel	8600	4	1725

Based on the life span, we calculate the cost per product

$$c_{осн} = \frac{C}{N} = \frac{1720}{7000} = 0.24RUB$$

Где: С – цена оснащения, N – количество деталей в год.

Calculation of costs under the item "General shop costs”

It should been taken 50-80% of basic salary of workers.

It can be calculated with the formula

$$C_{оп} = C_{озп} \cdot k_{оп} = 37.5 \cdot 0{,}6 = 22.5руб; \quad k_{оп} = (0{,}5 - 0{,}8)$$

Calculation of costs under general business expenses

The calculation is made using the coefficient $k_{ох}$, which establishes a normative relationship between the value of these costs and the basic wages of production workers. The recommended value is k0x = 0.5, i.e

$$C_{ох} = C_{озп} \cdot k_{ох} = 37.5 \cdot 0{,}5 = 18.75\ руб.$$

Calculation of expenses under item "Expenses for realization"

These expenses are recommended to be taken equal to 1% of the production cost, i.e. from the amount of costs for all previous articles.

$$C_{ВН} = (C_{М} - C_{ОМ} + C_{ОЗП} + C_{дзп} + C_{Н} + C_{a} + C_{ЭКС} + C_{мэкс} + C_{ЗЛ.п} + C_{рем} + C_{ион} + C_{осн} + C_{on} + C_{ox}) \cdot 0.01 = (848.6 - 19.57 + 37.5 + 3.750 + 11.62 + 8.4 + 21.14 + 1.68 + 4.1 + 37.5 + 113 + 0.24 + 22.5 + 18.75) \cdot 0.01 = 6.75 rub$$

Calculation of Profit

The profit from the sale of the product, depending on the specific situation, can be determined in various ways. If the contractor does not have the data to apply the "complex" methods, then the profit should be taken in the amount of 5-20% of the full cost of the project. The calculation can be carried out with the formula;

$$C_{np} = (C_{М} + C_{ОЗП} + C_{дзп} + C_{Н} + C_{a} + C_{ЭКС} + C_{мэкс} + C_{ЗЛ.п} + C_{рем} + C_{ион} + C_{осн} + C_{on} + C_{ox} + C_{вн}) \cdot 0.18 = (848.6 + 37.5 + 3.750 + 11.62 + 8.4 + 21.14 + 1.68 + 4.1 + 37.5 + 113 + 0.24 + 22.5 + 18.75 + 5.49) \cdot 0.01 = 204.74 rub$$

VAT CALCULATION

VAT is basically 18% of the total cost of products and profit i.e;

$$C_{НДС} = (1115.22 + 204.74) \cdot 0.18 = 1315.96 RUB$$

PRICE OF PRODUCT

The price of the product/part is equal to the sum of the full cost price, VAT and Profit i.e;

price of the product=$(1115.22 + 204.74 + 236.87) = 1552{,}83 Rub$

TypeofCost	**Expenditure perUnit, ruble**
Cost of material	847,86
Cost of reusable material	19,57
Basic salary of workers	37,50

Additional salary	3,75
Taxes and deductions from the wage fund	11,62
Consumption and maintenancecost	186,06
Depreciation cost	8,4
Maintenance of equipment	21,14
Cost of materials spent for work equipment	1,68
Cost of electricity	4,1
Cost of repair	37,5
Cost of fixture and instruments	113,24
General economic expenses	22,5
All purpose cost	18,75
Expenses for realization	6,75
Total cost price	1115,22
Profit	200,74
Manufacturer whole sale price	1315,96
VAT (18%)	236,873
Selling whole sale price	1552,83

Conclusion

In summary, having calculated the cost of the product in different aspects I found that the total cost price is 1552,83 and then the selling price will be 1552,83 which is quit affordable for the costumers. In this case for production of this product we can use other materials like rolled stock or casting, but the rolled stock should have a bigger diameter so it will be expensive in the market and it is almost impossible to manufacture.

However, the most reliable way of producing this part is with the use of stamping/die-forging in which the material is cheap and reduces wastage of materials during machining and the cost of social amenities are basically low.

5. SOCIAL RESPONSIBILITY

Student:

Group	Last, first name
8Л4И	Otokuefor Jerome Tseyi

School	The School of Advanced Manufacturing Technology (ScAMT)
Major	15.03.01 “Mechanical engineering”
Division of School	Division for Materials Science (DMS)

Initial data to the section "Social responsibility":	
1. Characteristics of the object of investigation (substance, material, instrument, algorithm, technique, working area) and the field of its application	*To Analyze harmful and dangerous factors in the process of manufacturing a flange.*
List of issues to be investigated, designed and developed:	
1. Production safety 1.1. Analysis of identified harmful factors in the development and operation of the proposed solution. 1.2. Analysis of identified hazards in the design and operation of the projected solution.	*Analyze harmful and dangerous factors in the workplace:1.1* *1. Deviation of the microclimate indices in the room;* *2. Increased noise level in the workplace;* *3. Insufficient illumination of the working area;* *1. Danger of electric shock;* *2. Fire hazard.*
2. Environmental safety Analysis of the impact of the object on the	*Analyze the negative impact on the environment.*

environment.	
3. Safetyinemergencysituations	*Development of measures to prevent the most typical emergency for the educational building (fire).*
4. Legal and organizational issues of security: Organizational arrangements for the layout of the work area.	*Analyze the compliance of the workplace with technical requirements and sanitary standards.*

The assignment was issued by:

Post	Last, First, middle name	Scientific degree, Grade	Signature	Date
Professor of Department of Control and Diagnostic	Nazarenko O.B.	D.Sc.		

The assignment was executed by the student:

Group	Last, First name	Signature	Date
8Л4И	Otokuefor Jerome Tseyi		

5. Social responsibility and Safety Management

This segment is dedicated to the examination and development of measures to ensure positive working conditions used for creative work of an engineer-manufacturer. It addresses issues of industrial safety, ergonomics, fire safety and environmental protection.

Introduction

Technical progress has made a major change in the conditions of knowledge of workers in industrial activity. Their work has become more intensive, requiring major venture of mental, emotional and physical energy. This required a complete solution of problems of ergonomics, hygiene and labor organization, regulation of modes of work and rest.

At the present time computer technology is broadly used in all fields of human action. When working with the computer the person is uncovered to a number of risky and injurious production factors: electromagnetic fields (frequency range: 5 Hz to 2 kHz, 2 kHz - 400 kHz), ionizing radiation, noise, static electricity, etc.Of great importance for the coherent design and layout of the workplace is to sustain an best possible working stance of the human operator.

4.1 Analysis of dangerous and harmful factors.

The manufacture settings in the workplace are characterized by the presence of some dangerous and harmful factors (GOST 12.0.002-80 "SSBT. Basic concepts terms and definitions"), which are basically classified by groups of rudiments: physical, chemical, biological and also psycho-physiological (GOST 12.0.003-74 "SSBT. Dangerous and harmful factors categorization").

On running at the computer engineer can have a miserable influence following dangerous and harmful production factors:

1. Physical: high levels of electromagnetic, x-ray, radiation, the lack of natural light, scarce non-natural illumination of the working area, elevated intensity, increased

contrast, a straight and a reflected best rate, extreme dust, risk of electric shock, noise from tools operation.

2. Chemical: elevated content in the air of working sector of carbon dioxide.

3. Psychophysical: eyestrain and deliberation; rational, disturbing, and long-drawn-out static loads; the repetitiveness of work; a big amount of information processed per unit time; inefficient organization of the workplace.

4.1.1 Industrial noise

The noise dis-organizes the conditions causing a harmful effect on the human body. Working in conditions of prolonged noise exposure, the worker experience irritability, headaches, dizziness, memory loss, fatigue, loss of appetite, pain in the ears, etc. Such violations in a number of organs and systems of the human body can cause a negative change in emotional state of a person up to stress. Under the influence of the noise reduced concentration, physiological functions are violated; there is fatigue due to increased energy costs and mental stress, deteriorating speech switching. All this reduces the efficiency, productivity, quality and safety. Prolonged exposure to intense noise [above 80 dBA] at the hearing of the person leads to its partial or total loss.

The main sources of noise in the office are fans of the power supply units of the computer. The noise level ranges from 35 to 60 dB. By SanPiN 2.2.2.542-96 in carrying out the basic work on the computer is the sound level at the workplace should not exceed 50 dBA. To reduce noise walls and ceiling of the room where there is a computer can be lined with sound absorbing materials.

4.1.2 Electromagnetic and ionizing radiation:

Scientists believe that both short and prolonged exposure to all types of radiation from the monitor is not dangerous for the health of the personnel operating the machines. However, comprehensive data on the risk of radiation exposure from the monitors at working with computers does not exist and research in this direction continues.

Valid values for the parameters of non-ionizing electromagnetic radiation from your computer monitor are represented in table. 4.1below.

The maximum level of x-ray radiation in the workplace of the operator of the computer does not exceed per/h, and the intensity of ultraviolet and infrared radiation from the screen of the monitor lies within the range of 10…100mWt/m^2.

Table 4.1 - Values for the parameters of non-ionizing electromagnetic radiation (in accordance with SanPiN2.2.2/2.4.1340-03)

Parameters name electricity		
Magnetic flux density	in the frequency range 5 Hz - 2 kHz	250 nT
	in the frequency range 2 kHz - 400 kHz	25 nT
The electro static field		15 kV/m

To reduce the impact of these types of radiation, monitors are recommended for use with low level radiation (MPR-II, TCO-92, TCO-99), install protective screens, and comprehend with regulated regimes of work and rest.

4.1.3 Electric shock

Dangerous factors of electric shock may include the presence in the premises of the large amount of equipment that uses single-phase electric current voltage of 220 V and frequency 50 Hz. The danger of electrocution study relates to the premises without increased risk, because of lack of humidity, high temperature, conductive dust and the possibility of simultaneous contact with the ground bonding metal objects and metal equipment housings when not properly earthed.

During normal operation of the equipment danger electrocution small, however, possible modes, called emergency, when there is a random electrical connection of parts under voltage with grounded structures.

Defeat by an electric current or by an electric arc may occur in the following cases:

- When touching live parts during repair;

- Single-phase (single pole) touch non-insulated from the ground of the person to un-insulated live parts of electrical installations under tension;

- In contact with the floor and walls, trapped under voltage;

- If possible short circuit in the high voltage units: the power unit, the scanner monitor.

The main measures to ensure electrical safety are:

- Fencing live parts, eliminating the possibility of accidental contact with them;

- Install protective earthen;

- The existence of a common switch;

- Timely inspection of technical equipment, insulation.

4.2 Ergonomic analysis of the work process.

4.2.1 The microclimate

The parameters of the microclimate can vary within wide limits, while a necessary condition of human life is to maintain constancy of body temperature through thermoregulation, i.e. the body's ability to regulate heat loss to the environment. The principle of normalization of microclimate is creation of optimal conditions for heat exchange of human body with the environment.

Computer science is a source of significant heat, which may result in increase of temperature and decrease of relative humidity in the room. In areas where there are computers, should conform to the defined parameters of the microclimate. Sanitary norms SanPiN 2.2.4.548-96, SanPiN 2.2.2/2.4.1340-03 set the values of parameters of microclimate, creating a comfortable environment. These standards are set depending on the time of the year, the nature of the labour process and the nature of the workplace (tab. 4.2).

The volume of the premises occupied by employees of the data center is greater than19.5 m^3/person. Feed rate of the fresh air into the premises, where the computers are given in table. 4.3.

Table4.2.The parameters of the microclimate in rooms where computers

The period of the year	The microclimate parameter	Value
Cold	The temperature of the air in the room	22…24°C
	Relative humidity	40…60%
	The speed of air movement	up to 0,1m/s
Warm	The temperature of the air in the room	23…25°C
	Relative humidity	40…60%
	The speed of air movement	0,1…0,m/s

Table 4.3 - Regulations for supplying fresh air to the rooms where the computers are located

Description of room	Volume flow supplied to the premises of fresh air, m^3 /per person per hour
Volume up to $20m^3$ per person	Not less than 30
$20...40m^3$person	Not less than 20

Ensuring, comfortable conditions are used as organizational methods (rational organization of work, depending on time of day and year, the alternation of work and rest) and technical equipment (ventilation, air conditioning, heating system).

4.2.2 Lighting

Properly designed and implemented industrial lighting improves visual work, reduces fatigue, improves productivity, positively affects the production environment, providing a positive psychological impact on employees, increases safety and reduces injuries.

Insufficient lighting results in eye strain, weakens attention and leads to the onset of premature fatigue. Overly brightened lighting causes glare, irritation and eye pains etc. Wrong direction of light in the workplace can create harsh shadows, glare, confusion. All these reasons can lead to an accident or occupational diseases, hence the importance of a correct calculation of illumination.

There are three types of lighting

- Natural Lighting
- Artificial lighting
- Combined (natural and artificial).

Natural lighting – daylight uses penetrating through the light apertures in the outer walling of the premises. Natural light is characterized in that it varies widely depending on time of day, time of year, the nature of the field and a number of other factors.

Artificial lighting: Is utilized when working in the dark and during the day when you are unable to provide normalized values of the coefficient of natural light (cloudy weather, short daylight hours). Lighting, which is insufficient according to the norms of natural light supplemented with artificial, is called a combined lighting.

Artificial lighting is divided into operating, emergency, evacuation, security. Illumination, in turn, can be shared or combined. Total - lighting in which the lamps are placed in the upper zone of the room evenly or in relation to the location of the equipment. Combo – lighting is that added to the total local lighting.

According to SP 52.13330.2011 "Natural and artificial lighting, actualized edition of SNiP 23-05-95" in the premises of the data center you want to apply a combined lighting system.

When carrying high visual accuracy (the smallest size of an object distinguish between 0.3...0.5 mm) the coefficient of natural lighting (KEO) should not be below 1.5% when visual work average precision (smallest size of an object distinguish between 0,5...1,0 mm) KEO should not be below 1.0%. As sources of artificial light typically use fluorescent lamps type LB or DRL, which are combined in pairs in the lamps, which must be placed above the working surfaces evenly.

Requirements for lighting in rooms with computers, the following: when you run the visual works of high precision General illumination shall be LC, and combined - LC; similar requirements when performing work average precision - 200 and LC respectively.

4.2.3 Ergonomic requirements to the workplace

Design of workplaces, equipped with terminals, is among the important problems of ergonomic design in computer science.

Working place and relative location of all of its elements must correspond to the anthropometric, physical and psychological requirements. Of great importance is also the nature of the work, in particular, when workplace design engineer must meet the following basic conditions: optimal placement of equipment that is part of the workplace and sufficient working space that allows you to perform all the necessary movements and displacement.

Ergonomic aspects of design Video terminal jobs, in particular, are: the height of the working surface, the size of legroom, location requirements documents in the workplace (availability and sizes stand for documents, varying placement, the distance from the user's eyes to screen, document, keyboard, etc.), characteristics of the work chair, requirements to the table surface.

The main elements of the workplace and engineering are the Desk and chair. The main working position is the sitting position.

Working sitting posture causes minimal fatigue engineer. The rational layout of the workplace provides a clear procedure and the permanence of the placement of objects, tools and documentation. It is required to perform work more often located in the zone of easy reach of the workspace.

Motor field is space of the workplace, which can be a physical action of a person.

The maximum range of the hands is a part of the motor field workplace, limited arcs described by the maximally outstretched arms during their movement in the shoulder joint.

The optimal zone is a part of the motor field workplace, limited arcs described by the forearm when moving the elbow with support at the point of the elbow and with relatively immobile shoulder.

Optimal placement of items of work and documentation in the areas of distance:

The DISPLAY is located in zone а (center);

The SYSTEM UNIT is provided in the recess of the table;

KEYBOARD - in zone г/д;

"MOUSE" - in the right;

The SCANNER in the zone а/Б (left);

The PRINTER is in zone а (right);

DOCUMENTATION: required when working in the area easy reach of palms, and in the drawers of table - literature, constantly unused.

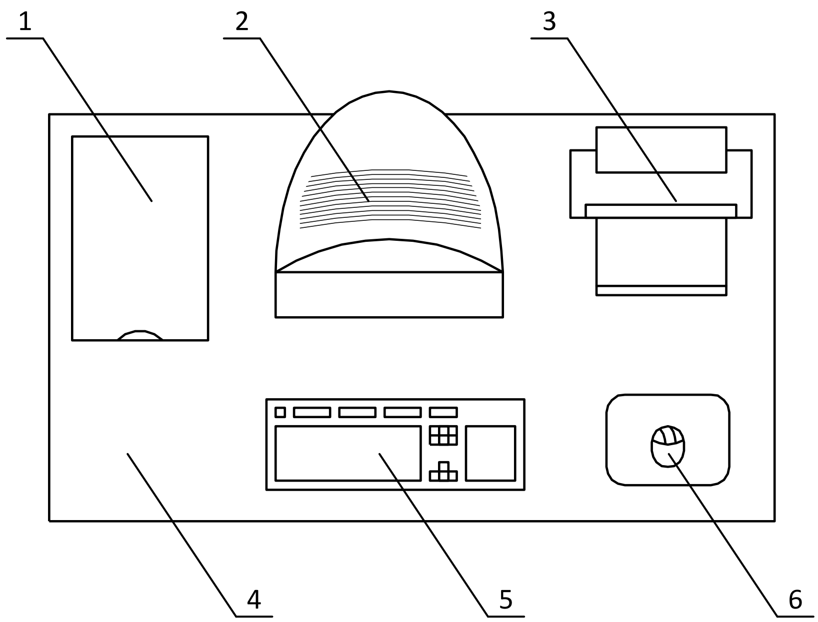


Fig. 5.2. Personal computer’s components

In Fig. 2 above shows an example of placement of the main and peripheral components of a PC on the desktop programmer.

1 scanner, 2 – monitor, 3 – printer 4 – the surface of the desktop,

5 – key-board 6 – manipulator of type "mouse".

For comfortable work Desk should satisfy the following conditions:

- The height of the table should be selected based on the ability to sit freely in a comfortable pose, if necessary, based on the armrests;

- The lower part of the table needs to be designed to be able to sit comfortably, was not forced draw in the legs;

- The surface of the table must have the following properties, eliminates glare in the field of view of the programmer;

- The design of the table should have drawers (at least 3 for documentation, listings, stationery).

- The height of the work surface is recommended in the range of 680-760mm. The height of the surface onto which the keyboard is placed should be about 650mm.

Great importance is attached to the characteristics of the Desk chair. So, recommended seat height above floor level is in the range of 420-550mm. The seat surface is soft, the front edge rounded, and the back angle is adjustable.

It is necessary to include in the design the possibility of posting documents: at the side of the terminal, between the monitor and keyboard, etc. in addition, in cases where the video display is of low quality images, such as visible flicker, the distance from the eye to the screen make more (about 700 mm) than the distance from the eye to the document (300-450mm).Generally with a high quality image on the video display the distance from your eyes to screen, document and keyboard to be equal.

The screen position is determined by:

- Reading distance of (0.6...0.7 m);

- Angle reading, the viewing direction 20° below the horizontal toward the center of the screen, and the screen perpendicular to this direction.

Must also be capable of regulating the screen:

- Height +3 cm;

- Tilt from -10° to +20° relative to the vertical;

- In left and right directions.

Of great importance for the correct working posture of the user.When uncomfortable working position may have pain in the muscles, joints and tendons. The requirements for the operating posture of the user video terminal the following:

- The head should not be tilted more than 20°,

- Shoulders should be relaxed,

- Elbows - angle of 80°...100°,- forearms and hands in a horizontal position.

The reason for poor posture of users due to the following factors: there is a good stand for documents, the keyboard is too high, and documents - low, no place to put hands and arms, not enough leg-room.

In order to overcome these drawbacks provide General advice: better mobile keyboard; must be provided with special devices for adjusting the height of the Desk, keyboard and screen and the palm rest.

Essential for productive and quality work at the computer to have the dimensions of the labels, the density of their placement, contrast ratio and brightness of the characters and background screen. If the distance from the eye of the operator to the display screen is 60...80 cm, the height of the sign shall be not less than 3mm, the optimal ratio of the width and height of the sign is 3:4, and the distance between the marks – 15...20% of their height. The ratio of the brightness of the screen background and characters should be from 1:2 to 1:15.

While using the computer, the physicians are advised to install the monitor at a distance of 50-60 cm from the eye. Experts also believe that the upper part of the video display should be at eye level or slightly below. When a person looks straight ahead, his eyes are opened wider than when he looks down. Due to this, the area is significantly increased, causing dehydration of the eyes. Besides, if the screen is mounted high and eyes wide open, disturbed function of blinking. This means that the eye does not close completely, not washed by the lachrymal fluid, do not receive sufficient moisture, leading to fatigue.

The creation of favorable working conditions and the right aesthetic design jobs in manufacturing is of great importance both to facilitate and to enhance its attractiveness, positive impact on productivity.

4.3. Development of measures of protection from dangerous and harmful factors

As measures to reduce noise it is possible to propose the following:

1. Veneer ceiling and walls with sound-absorbing material (reduces noise by 6-8 dB);

2. Shielding the workplace (raising of walls, diaphragms);

3. Installation in computer rooms equipment, producing minimal noise;

4. The rational layout of the room.

Protection from noise should be performed in accordance with GOST 12.1.003-83 "Noise. General safety requirements and sound insulation of enclosures shall meet the requirements of Chapter SNiP 23-03-2003 "Protection against noise. Design standards".

When protection against external radiation arising from work with display, take the following actions:

According to SanPiN 2.2.2/2.4.1340-03 for optimal health and maintaining health during the work shift must be installed regulated breaks – when 8-hour day duration 15 minutes every hour;

1. The display is set so that from the screen to the operator not less than 60-70 cm;

2. Must be used in displays with built-in protective screens.

3. Electrical safety technical ways and means:

Since all live parts of the computer are isolated, accidental contact with live parts is excluded.

To provide protection from electric shock when touching metal natco-web parts that may be under stress as a result of damage to the insulation, it is recommended to use protective grounding.

Chassis ground of the computer is provided by summing the grounding conductor to the supply outlets. There must be grounding resistance of 4Ω, according to (PUE) for electrical installations with voltage up to 1000 V.

Organizational measures to ensure electrical safety:

The main organizational activity is instruction and training in safe methods of work, as well as a test of knowledge of safety rules and instructions in accordance with the position in relation to the work performed.

When performing unscheduled and scheduled maintenance of computing the following steps:

- Remove computer from network

- Voltage testing

After performing these steps we proceed to the repair of faulty equipment.

If the repair is carried out on live parts under voltage, execution of work is carried out by at least two individuals with means of electrical safety.

4.4.1 Fire safety

The fire in the study, can lead to very adverse consequences (loss of valuable information, property damage, loss of life, etc.), it is therefore necessary to identify and eliminate all causes of fire; to develop a plan of measures for the elimination of fire in the building; the plan of evacuation of people from buildings.

The causes of fire can be:

– Malfunction wiring, sockets and switches which may cause a short circuit or breakdown of insulation;

–Damaged (defective) electrical appliances;

– Use indoor electric heaters with open heating elements;

– The occurrence of a fire due to a lightning strike to the building;

– Fire building due to external influences;

– Careless handling of fire or non-observance of fire safety.

4.4.2 Prevention of fire

Fire prevention is a complex of organizational and technical measures aimed at ensuring the safety of people on the prevention of fire, limiting its distribution and also creation of conditions for successful fire extinguishing. For the prevention of fire is extremely important proper fire risk assessment of buildings, identification of hazards and justification of the ways and means of protection.

Modern computers come with a very high density of elements of electronic circuits.

In close proximity to each other are arranged to the connecting cord, patch cords. When flowing over them electric current is allocated a significant amount of heat, which may result in raising the temperature to 80°-100°C, it is possible to melt the insulation of the connecting wires, their exposure, and, as a result, a short circuit.

For removal of excess heat from computers serve as ventilation and air conditioning. However, they can be an additional fire hazard to the building if the fire spread.

The premise computing laboratory for explosion safety concerns to the category (in accordance with the Federal law from July, 22nd, 2008 N 123-FZ "Technical regulations on fire safety requirements").

One of the conditions of fire safety is the elimination of possible ignition sources.

In the office of the ignition sources can be:

– faulty electrical faults in wiring, electrical outlets and switches. To eliminate the risk of fire for these reasons, it is necessary to identify and eliminate defects, carry out routine inspection and eliminate all faults;

– Faulty electrical appliances. Necessary measures to prevent fire include the timely repair of electrical appliances, high-quality correction of damage that do not use faulty electrical appliances;

– Space heating electric heaters with open heating elements. Open heating surface can cause a fire, as in the room are paper documents and reference materials in the form of books, manuals, and paper – flammable object. In order to prevent fire, do not use outdoor heaters indoors;

– Short circuit in the wiring. In order to reduce the probability of fire due to short circuit it is necessary that the wiring was hidden.

– getting into the building from lightning. In summer during a thunderstorm, possibly a lightning strike might result in possible fire. To avoid this, it is recommended to install on the roof of the lightning arrester;

– Non-observance of measures of fire safety and Smoking indoors can also lead to fire. To eliminate the ignition as a result of Smoking indoors is recommended to strictly forbid Smoking, and allow only in strictly designated place.

In order to prevent fire hold with engineers working in the room, fire drill, has to be familiarized between employees with fire safety rules, and to teach the use of primary fire extinguishing means.

In the event of a fire you must first disconnect the power, to call the fire Department, evacuate people from the premises in accordance with the evacuation plan and proceed to extinguish the fire with fire extinguishers. If there is a small hearth fire, you can use the means at hand for the purpose of preventing access of air to the object of fire.

In the laboratory are the primary means of fire suppression, a box of dry sand, water, asbestos blankets, manual powder extinguisher OP - 4. To prevent fire and fire prevention systematically conducted inspection of electrical circuits and equipment are detected early and eliminated the fault. The laboratory has developed an evacuation plan, which made available to the laboratory staff.

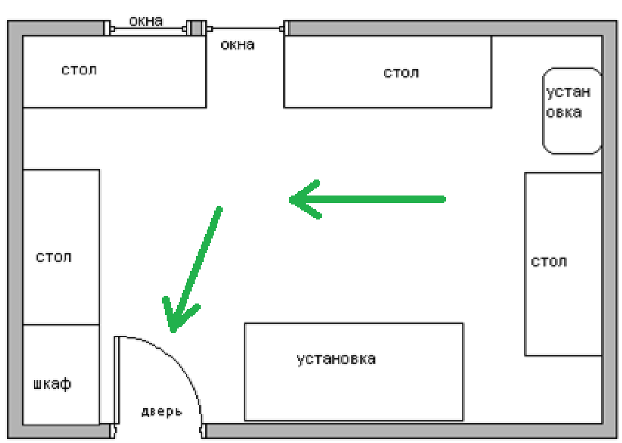


Fig.3.The evacuation plan

9.5 Environmental Protection

Environmental protection is really important and meaningful process. That is why these issues are devoting a lot of time and attention. Environment is the complex of measures aimed at preventing the negative impact of human activity on nature, providing favorable and safe conditions of human life.

Creation of conditions for improvement of ecological conditions - the process is long, requires coherence and consistency of action. Priority in the environmental policy of the Russian Federation today the following questions:

- Ensuring environmentally safe living conditions;
- Rational use and protection of natural resources;
- ensuring environmental and radiation safety (MPE);
- The greening of industry;
- Increase of ecological culture of society and the formation of ecological consciousness in humans.

Important role in the protection of the environment is given to the procedures for the rational placement of the sources of contaminants. These include:

1) Making industrial enterprises of major cities and new construction in sparsely populated areas with unsuitable and unsuitable for agricultural use of land;

2) The optimum location of industrial enterprises taking into account the topography of the terrain and the wind rose;

3) Establishment of sanitary protection zones around industrial plants.

4) The rational layout of the urban area, providing optimal environmental conditions for humans and plants.

In the environment play an important role in the quality of the environment designed to conduct systematic monitoring of the condition of the atmosphere, water and soil for the actual levels of pollution. The information obtained about the dirt allows you to quickly identify the causes of increasing concentrations of harmful substances in the environment and actively to fix them.

Environmental protection is a complex problem that requires the efforts of scientists of many specialties. Of particular importance is the quantitative assessment of the impact of environmental pollution and, above all, damage to the national economy of pollution. Protecting the environment from contamination at the present stage in addition to economic objectives are increasing social productivity and also includes socio-economic task of improving the conditions of human life, the preservation of his health.

To minimize the level of pollution emitted by the enterprises, it is necessary to make the following mandatory measures for the environmental protection (EP). Measures for environmental protection are:

1. The identification, assessment, permanent control and limitation of harmful emissions into the environment, creating environmental and resource-saving technologies and equipment.

2. The development of legal laws, legal acts on protection of the natural environment, as well as material incentives for compliance with these laws and environmental measures.

3. The prevention of environmental degradation and the environment from harmful and hazardous factors through the creation of dedicated areas (SPZ).

Non-waste technology is the most active form of protection of the environment from the harmful effects of industrial emissions. Under the concept of "soft technology" is understood as the set of activities in production processes from raw materials to ready-made products, thereby reducing to a minimum the amount of harmful emissions and reduces the impact of waste on the environment to an acceptable level. In this set of activities includes:

1) Creation and implementation of new processes for products with the formation of the least amount of waste;

2) Development of various types of closed technological systems and water cycles on the basis of methods of wastewater treatment;

3) Development of systems for recycling of production waste into secondary materials;

4) Creation of territorial-industrial complexes having a loop structure material flows of raw materials and waste inside the complex.

Until full implementation of non-waste technology important areas of greening of industrial production should be considered:

1) Improvement of technological processes and development of new equipment with lower emissions of pollutants and waste into the environment;

2) The replacement of toxic waste on non-toxic;

3) Replacement of non-recyclable waste recyclable;

4) The use of passive methods of environmental protection.

Passive methods of protection of the environment include a complex of measures to limit emissions from industrial production and subsequent recovery or disposal of waste. These include:

- Treatment of wastewater from impurities;
- Treatment of gaseous emissions of harmful impurities;
- The dispersion of harmful emissions into the atmosphere;
- Suppress noise in its distribution;
- Measures to reduce levels of infrasound, ultrasound and vibration in their ways of spreading;

Enterprises, individual buildings and facilities production processes that are sources of negative impact on the environment and human health, should be separated from residential buildings sanitary-protective zones.

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