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

Faculty of Engineering of Machines, Structures and Technologies
(full name of faculty)
Mechanical Engineering Technology
(full name of department)

QUALIFYING PAPER

For the degree of

bachelor
(degree name)

topic: Improving the Technological Process of Mechanical Processing of the Flange

746.647.008

Submitted by: fourth year student 4 , group ІМП-42
specialty 131 «Applied Mechanics»
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Ternopil 2022

ABSTRACT

Key words: Flange, technological process, operation, milling, drilling, work piece.

The purpose of the work is to improve the technology of manufacturing the flange with the appropriate justification.

To achieve this goat, the following tasks are solved.

The first section analyzes the design features of the flange 746.647.008, its application, technical requirements for surfaces, its manufacturbility. The basic technological process was considered in detail.

In the second section we determined the type of production, choose the best option for manufacturing the work piece-stamping. Conducted a synthesis of the technological route of machining parts, determined the allowances and inter-operational dimensions. Carried out the choice of tools, equipment.

The third section presents the design and principle of operation of the device for simultaneous drilling of 4 holes. Milling plane, calculated their accuracy and power parameters.

In the fourth chapter, the issues of life safety and basics of labor protection are considered.

Relevant conclusions and a list of references are presented

CONTENT

INTRODUCTION

In the qualification work of the bachelor, the technological process of mechanical processing of the flange 746.647.008 is improved. The part is a component of the drive of the mixing system of the grain binder and is designed centering and fixing the spray mechanism. It is made of structural steel 35. The work-piece is obtained by hot stamping in presses, according to the type of production, material, as well as the condition of obtaining economic effect.

In the basic technological process of manufacturing of flange parts 746.647.008 at the enterprise for serial production of the following main parameters are used: for machining of parts universal adjusting devices are used as technological equipment; universal metal-cutting equipment of normal accuracy is used; application of universal measuring instruments to control the accuracy and roughness of treated surfaces; use of universal standard cutting tools for machining work-pieces; the concentration of operations of the basic technological process corresponded to the serial type of production.

Aim: To improve the technological process of mechanical processing of the flange with appropriate justification.

1 General technical part

1.1. Official purpose of the part

A Flange is a reliable way to connect pipe systems with the various equipment, valves, and other components of virtually any processing system, flanges are the second most used joining method after welding. Using flanges adds flexibility when maintaining piping systems by allowing for easier disassembly and improved access to system components.

A typical flanged connection is comprised of three parts:

- Pipe Flanges
- Gasket
- Bolting

In most cases, there are specific gasket and bolting materials made from the same, or approved materials as the piping components you wish to connect. Stainless Steel flanges are some of the most common. However, flanges are available in a wide range of materials so matching them with your needs is essential.

Other common flange materials include Monel, Inconel, Chrome Moly, and many others depending on the application.

The best option for your needs will depend on both the system in which you intend to use the flange and your specific requirements.

Designation of surfaces of a detail is shown in figure 1.1. Therefore, pursuant to the design purpose, the main surfaces of the flange are the surfaces B, V, Y, G, K, P, H, H1, which are used for mounting, centering, and support. Surfaces A, D, E, D1, E1, Z, L, R, O, I, U, P, N, M, F, X, are auxiliary and are intended for installation or fixing of auxiliary accessories, serve as technological bases, form product design.

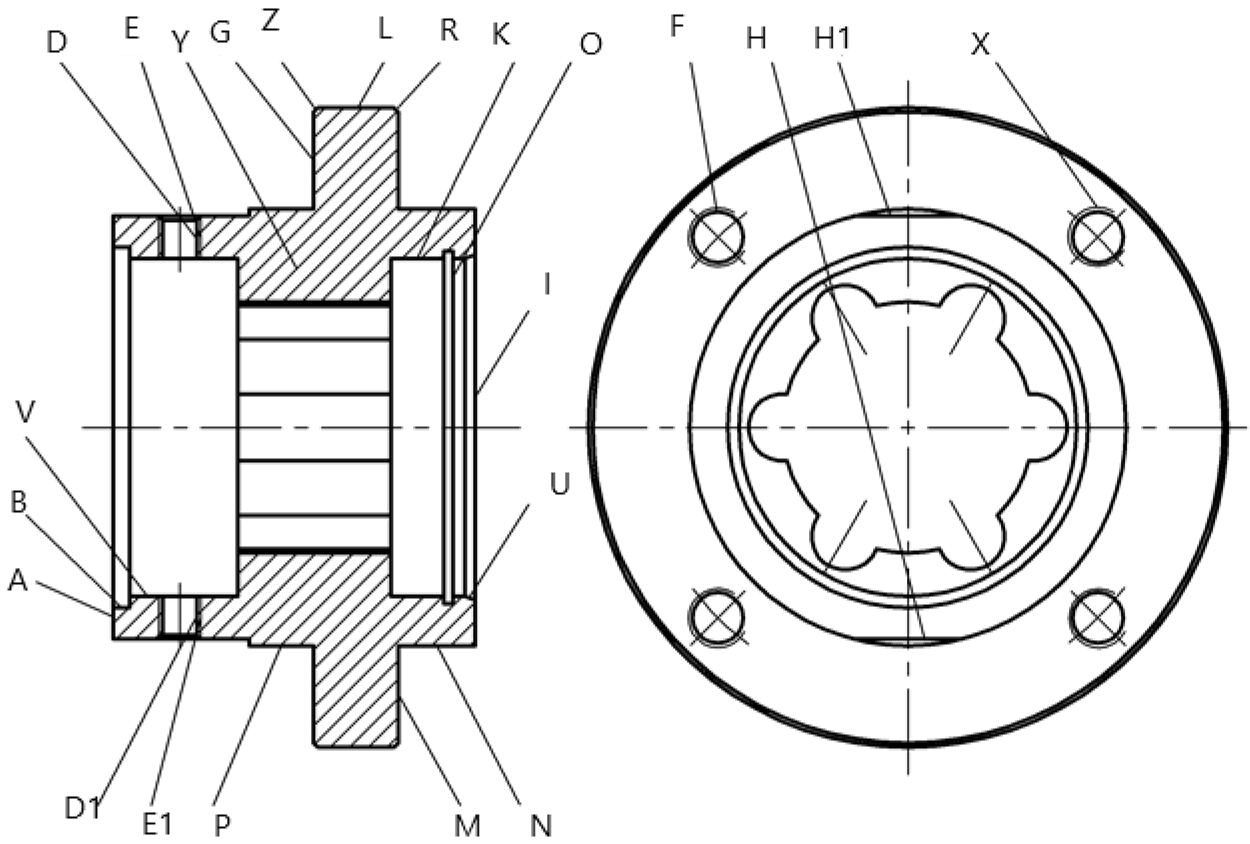


Figure 1.1 Designation of surfaces of a detail

Surfaces B. B are designed to install and center the sleeve in the flange when assembling the unit. In particular, the requirements for the surface B are the tolerance for radial beating not more than 0.01 mm. Deviation from the roundness of the surface B, relative to the same surface B, not more than 0.05 mm in diameter, roughness Ra = 6.3 µm.

Surface B is processed according to the 8th quality of accuracy. The main functional purpose and basic for most machining operations is surface B. Surface K is designed to install a cuff that prevents the loss of grain materials and pesticides from falling out of the mixer hopper and the ingress of foreign elements into the mixing zone. This surface is treated according to the 9th quality with a roughness of s Ra = 1.6 µm.

The detail is made of steel of grade 35 of GOST 1050-88. This material is supplied in the form of rolled products, forgings with guaranteed chemical composition and mechanical properties. Chemical and ,mechanical properties if steel 35 are given in tables 1.1 and 1.2

Table 1.1 - Chemical Composition of Steel 35 GOST 1050-88

Brand of material	Content of chemical elements						
	C, %	Mn, %	Si, %	S, %	P, %	Cr, %	Ni, %
				Not more			
Steel 35	0,32÷0,4	0,5÷0,8	0,17÷0,37	0,04	0,04	0,25	0,25

Table 1.2 – Mechanical properties of steel 35 GOST 1050-88

Brand of material	Characteristics					
	B, Mpa	T, Mpa	δ_5, %	ψ, %	KCU, J/см^2	HB
Steel 35	530	315	20	45	69	150…175

1.2. Analysis of Technical Requirements of the Part

The work-piece of the part “flange 746.647.008” is a a forging of group I, obtained by free forging. This method of obtaining the work-piece is not difficult, but the accuracy of the workpiece is low, and therefore it is advisable to increase its accuracy, which will also reduce allowances for machining of critical surfaces of the part, increase the utilization of the material and reduce the weight of the work-piece. The material of the product is not scarce and expensive, its mechanical properties meet the technological and operational requirements, respectively,as a blank you can use forging obtained by hot stamping in presses.

We will analyze the basic technical requirements for the surfaces of the part with the establishment of methods of their implementation of control. Date from the analysis of technical conditions for manufacturing are summarized in Table 1.3

Table 1.3- Analysis of Technical Conditions

Marking	Technical Condition or Requirement	Method of Execution	Control Method
1	2	3	4
B	Roughness *Ra* = 6,3 µm.; precision accuracy surface on the 8^{th} quality; deviation from roundness no more than 0.05mm	Finish turning in roughness template	Roughness Samples Special control device
V	End beat no more than 0.01mm	Turning in special devices	Special control device
K	Roughness Ra = 1.6 µm; surface accuracy on the 9th quality; deviation from roundness no more than 0,05 mm	Finishing/Net turning in a special devices	Roughness samples,, template,special control device

Therefore, analyzing the design of the part, it can be stated that the product has sufficient rigidity machining with various cutting tools, and also it is possible to fix it in various technological devices without violating its geometric dimensions and shapes.

It is expedient to carry out mechanical processing of a detail in special devices with installation on fingers, and also use of self-centering turning cartridges with a pneumatic clamp.

1.3. Analysis of the manufacturability of the design of the part

The level of manufacturability of the structure on the accuracy of processing is characterized by the coefficient of accuracy, which is determined by the following formula [2]

$$K_{T.CH} = 1 - \frac{1}{T_{sr}}, \tag{1.1}$$

where TCP is the average numerical value of the precision parameter of the product

$$T_{sr} = \frac{\sum T_{n_i}}{\sum n_i} \tag{1.2}$$

where T is the numerical value of the parameter of processing accuracy (quality);

n_i - the number of dimensions of the corresponding accuracy class.

$$T_{sr} = \frac{2 \cdot 80 + 4 \cdot 1.6 + 0.8 + 3 \cdot 6.3}{10} \approx 18.61$$

Accordingly, the coefficient of roughness

$$K_{T.CH} = 1 - \frac{1}{12} = 0,91$$

Analyzing the values , the coefficients of manufacturability, we can conclude that it is necessary to choose a more technological way to obtain the workpiece and assign a calculated-tabular rational values of allowances for machining to reduce the weight of the workpiece and increase the utilization of the material.

1.4. Analysis of the Basic Technological Process

The basic technological process of manufacturing "flange 746.647.008" involves mass production. The technological process is characterized by a typical processing route for parts of this class.

Preliminary, it can be noted that the basic technological process of manufacturing a flange is imperfect, because it is tied to the equipment available at the enterprise, which, although it meets the requirements for quality, accuracy, surface roughness of the resulting part, but binds us to specific conditions of production. Accordingly, this technological process requires further elaboration in order to improve.

As for the bases, they are chosen correctly in accordance with the principle of their unity and permanence. The condition is also fulfilled that at the first operation those surfaces which further serve as base for other operations are processed. Some operations of the technological process should be replaced by more advanced ones, which would increase the productivity of processing.

In the first machning operation, the base is a cylindrical surface H of of the part, which is further processed by turning. The accuracy of of the base is increased by using pre-treated surfaces P and Zh.

In terms of reducing the cost of the product and the cost of pre-machining the surface E can not be pre-drilled, not drilled. This will reduce the total processing time as you will not need to reinstall the workpiece on another machine.

Operations 015 (lathe with CNC) and 055 (lathe-screw-cutting) should be carried out on a lathe multi-cutter semiautomatic, it will reduce equipment maintenance costs (reducing the number of machine tools and semi-automatic provides the necessary machining accuracy, and much cheaper than CNC machine). Operations 030,035 (vertical drilling) and 045, 060 (radial drilling) should be carried out on a multi-spindle vertical drilling machine, such as 2C135 instead of 2H135 and 2H55. This will reduce the cost of maintaining the equipment, the production area of the site and at the same time provide a higher load factor of the equipment and the required accuracy of processing, operation 060 can be omitted. No operation 050 (calibration) required. The accuracy and geometric shape of the slotted hole can be ensured by a horizontal-long operation in two transitions. Accordingly, there is no need for a press (P6324), and you can use the already involved horizontal-extended machine mod. 7B56.

Other operations of the basic TP can be left unchanged, as the method of processing and equipment used are modern and advanced.

It is also possible to improve the equipment of operations, which consists in the use of more advanced technological equipment, including for integrated control of the part, both receiving and processing.

1.5 Conclusions and tasks for the qualification work

As a result of the analysis of construction, manufacturability and basic technological process of machining of the part "flange 746.647.008" it can be concluded that in general the part is technological, does not cause special difficulties in manufacturing, material and construction of the part are sufficiently developed for manufacturability.

When performing the work it is necessary to improve the existing technological process in order to improve it according to the proposed measures, ie to develop the optimal technological process of machining, which should eliminate identified shortcomings in the basic technological process, choose modern technological equipment and necessary equipment, choose a more efficient way calculate allowances for processing, cutting modes and time norms for operations.It is necessary to select effective process equipment, equipment and the necessary cutting tools to perform the operations of the developed process, as well as the choice of device for machining, calculate the error of installation of parts in the proposed device, as well as calculation and selection of device drive.

In addition, it is necessary to consider the safety of life and the basics of labor protection in case of emergencies at the enterprise.

2 TECHNOLOGICAL PART

2.1 Establishing the type of production

The type of production is characterized by the coefficient of consolidation of operations. Its value is taken for the planning period of one month [2]

$$K_{zo} = O/P, \tag{2.1}$$

where O is the number of different operations;

P - the number of jobs with different operations.

Table 2.1 - Processing route and complexity of the basic technological process

№ operations	The Name of Operation	Equipment	Artificial time, min.
005	vertically drilling	2H135	0,96
010	vertically drilling	2H135	1,13
015	lathe with CNC	16К30Ф3	16,36
020	milling with CNC	6Р13Ф3	9,85
025	horizontally extended	7Б56	2,67
030	vertically drilling	2H135	0,75
035	vertically drilling	2H135	1,02
040	vertically drilling	2H135	1,82
045	radial drilling	2H55	1,15
050	calibration	Press P6324	0,45
055	screw-turning	16K20	0,49
060	milling with CNC	6Р13Ф3	2,04
065	radial drilling	2H55	3,92
070	locksmith	Bench	0,44
075	washing	M2A	0,35
080	control	PR 1466	1,28

Annual program production of parts N = 6000 pcs. Number of operations assigned to one workplace [2]

$$O = \frac{60 \cdot F_M \cdot k_v \cdot \eta}{T_{sht} \cdot N_M}$$

where *Fm* is the monthly fund of equipment operation in two-shift mode, hours *Fm* = 4015/12 = 334.5 years;

k_v - average coefficient of use of time norms, kv = 1,3;

n- average load factor of equipment, = 0.8;

T_{sht} - artificial time of use of operations on the machine (according to the basic technological process).

N_M- monthly program of parts production, pcs .;

N_M = N / 12 = 6000/12 = 500 pcs.

We calculate the number of operations assigned to one workplace

- operation 005 (vertical drilling):

$$O_1 = \frac{60 \cdot 334{,}5 \cdot 1{,}3 \cdot 0{,}8}{0{,}96 \cdot 500} = 42{,}59$$

- operation 010 (vertical drilling)

$$O_2 = \frac{60 \cdot 334{,}5 \cdot 1{,}3 \cdot 0{,}8}{1{,}13 \cdot 500} = 36{,}94$$

- operation 015 (turning with CNC)

$$O_3 = \frac{60 \cdot 334{,}5 \cdot 1{,}3 \cdot 0{,}8}{16{,}36 \cdot 500} = 2{,}55$$

- operation 020 (milling with CNC)

$$O_4 = \frac{60 \cdot 334,5 \cdot 1,3 \cdot 0,8}{9,85 \cdot 500} = 4,24$$

- operation 025 (horizontal-long)

$$O_5 = \frac{60 \cdot 334,5 \cdot 1,3 \cdot 0,8}{2,67 \cdot 500} = 15,75$$

- operation 030 (vertical drilling)

$$O_6 = \frac{60 \cdot 334,5 \cdot 1,3 \cdot 0,8}{0,75 \cdot 500} = 55,66$$

- operation 035 (vertical drilling)

$$O_7 = \frac{60 \cdot 334,5 \cdot 1,3 \cdot 0,8}{1,02 \cdot 500} = 40,93$$

- operation 040 (vertical drilling)

$$O_8 = \frac{60 \cdot 334,5 \cdot 1,3 \cdot 0,8}{1,82 \cdot 500} = 22,94$$

- operation 045 (radial drilling)

$$O_9 = \frac{60 \cdot 334,5 \cdot 1,3 \cdot 0,8}{1,15 \cdot 500} = 36,3$$

- operation 050 (calibration)

$$O_{10} = \frac{60 \cdot 334{,}5 \cdot 1{,}3 \cdot 0{,}8}{0{,}45 \cdot 500} = 92{,}77$$

- operation 055 (screw-turning)

$$O_{11} = \frac{60 \cdot 334{,}5 \cdot 1{,}3 \cdot 0{,}8}{0{,}49 \cdot 500} = 85{,}19$$

- operation 060 (milling with CNC)

$$O_{12} = \frac{60 \cdot 334{,}5 \cdot 1{,}3 \cdot 0{,}8}{2{,}04 \cdot 500} = 20{,}46$$

- operation 065 (radial drilling)

$$O_{13} = \frac{60 \cdot 334{,}5 \cdot 1{,}3 \cdot 0{,}8}{3{,}92 \cdot 500} = 10{,}65$$

Coefficient of consolidation of operations

$$K_{zo} = \frac{42{,}59+36{,}94+2{,}55+4{,}24+15{,}75+55{,}66+40{,}93+22{,}94+36{,}3+92{,}97+85{,}19+20{,}46+10{,}65}{13} = 35{,}93$$

Thus, the type of production is serial, as 20 ≤ Kzo ≤ 40 [2].

We carry out technical rationing of works for serial production. Release clock value [2]

$$t_V = \frac{F_D \cdot 60}{N}, \qquad (2.3)$$

where F_D is the actual annual time of equipment operation, hours; F_D= 4015; N - annual program of production of parts, pcs .; N = 6000 pcs.

$$t_v = \frac{4015 \cdot 60}{6000} = 40{,}15 \text{, min}$$

Number of parts for simultaneous commissioning [2]

$$n = \frac{N \cdot a}{F} \qquad (2.4)$$

where N is the annual program of production of parts, pcs .; N = 6000 pcs.
a - the number of days for which it is necessary to have a stock of parts, a = 5;
F - the number of working days in the year, F = 250 days.

$$n = \frac{6000 \cdot 5}{250} = 120 \text{ pcs}$$

2.2 Choosing a method of obtaining the workpiece

The method of obtaining the workpiece is determined by the design of the part, material, technical requirements, serial production, as well as cost-effectiveness of manufacture. The material of the part is steel 35, respectively, the workpiece can be obtained by the following methods [1]:
a) free forging;
b) hot stamping in presses.

Of the possible options for obtaining the workpiece is the one that after calculating the cost will be more economical. The cost of the workpiece can be calculated by the formula [2]

$$S_{zag} = \left(\frac{C_i}{1000} \cdot Q \cdot K_T \cdot K_C \cdot K_V \cdot K_M \cdot K_O \right) - (Q - q) \frac{S_{vidh}}{1000}, \qquad (2.5)$$

where C is the base cost of 1 ton of blanks, UAH;
K_T, K_C, K_V, K_M, K_O - coefficients that depend on the accuracy class; difficulty groups; tables; material brands; the volume of production of blanks;
Q - weight of the workpiece, kg;
The approximate weight of the workpiece can be found by the following formula [1]

$$Q = \gamma \cdot K_P \cdot V_d, \qquad (2.6)$$

where γ is the specific weight of the material, = 7.8 g / cm3;
K_P - coefficient that takes into account the presence of allowances, K_P = 1,02… 1,5;
V_d - the volume of the part (the volume of the part is the sum of the volumes of its components).
q is the weight of the finished product, q = 1.6 kg;
Svidh - the cost of 1 ton of waste, Svidh = 2850 UAH.

We calculate the cost of design blanks according to the decisions made (section 2.2).

Option 1: free forging

C_i = UAH 7,400; K_T = 1; K_C = 1.15; K_V = 1.3; K_M = 1; K_O = 1 [2]; K_P = 1.1.
g = 5.03 kg

$$S_{zag1} = \left(\frac{7400}{1000} \cdot 5,03 \cdot 1 \cdot 1,15 \cdot 1,3 \cdot 1 \cdot 1 \right) - (5,03 - 1,6) \frac{2850}{1000} = 45,87 \text{ UAH}$$

Option 2: hot stamping in presses

C_i = 8700 грн. [1]; K_T = 1; K_C = 1; K_V = 1,20; K_M = 1; K_O = 1 [2]; $K_П$ =1,02.

$$Q = 7,8 \cdot 1,09 \cdot 273,3 = 2324 \text{ г} \approx 2,32 \text{ кг}$$

$$S_{zag2} = \left(\frac{8700}{1000} \cdot 2,32 \cdot 1 \cdot 1 \cdot 1,2 \cdot 1 \cdot 1 \right) - \left(2,32 - 1,6 \right) \frac{2850}{1000} \approx 28,7 \text{ UAH.}$$

As we can see from the calculations, option 2 is more economical - hot stamping in the press. The economic effect on the release program is determined by comparing the two options

$$E_z = \left(S_{zag1} - S_{zag2} \right) \cdot N , \tag{2.7}$$

where N is the annual program of production of parts, pcs .; N = 6000 pcs.

$$E_z = \left(45,87 - 28,7 \right) \cdot 6000 = 103020 \text{ UAH}$$

The results of the calculations are summarized in table 2.2.

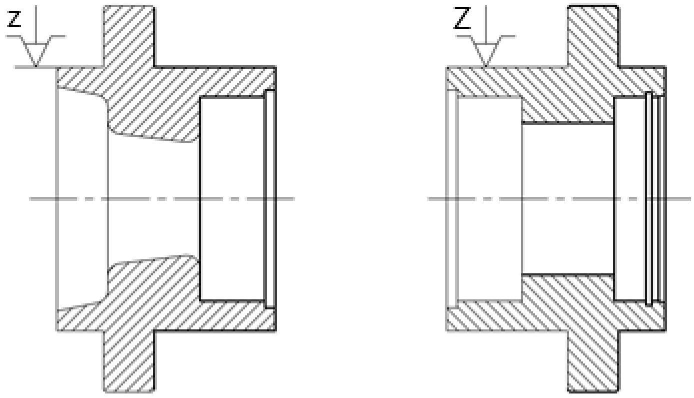
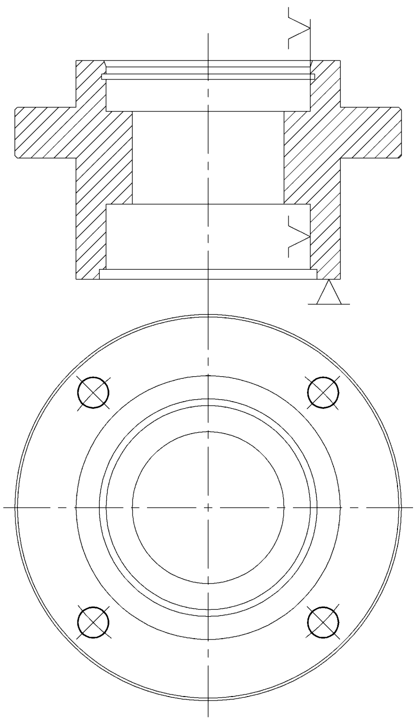
Table 2.2 - Comparative data of design blanks

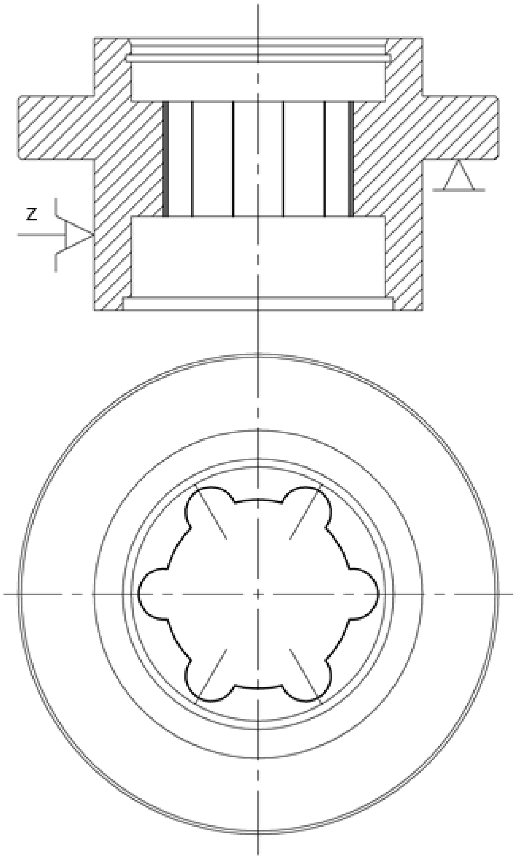
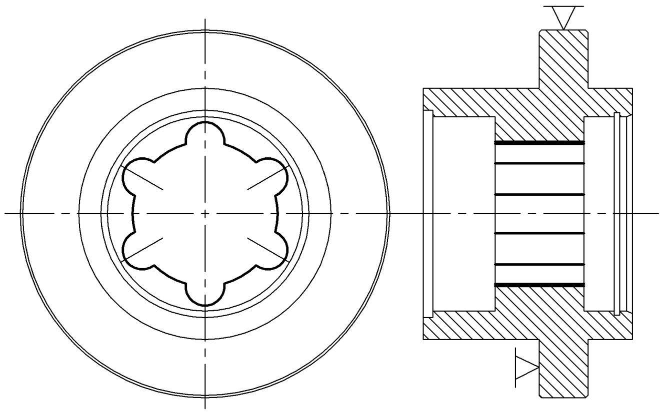
Characteristics of the workpiece	Variant	
	first	second
Type of workpiece	free forging	hot stamping in presses
Weight of details, kg	1,6	1,6
Weight of the workpiece, kg	5,03	2,32
The cost of the workpiece, UAH	45,87	28,7
Economic effect of the annual program, UAH	—	103020

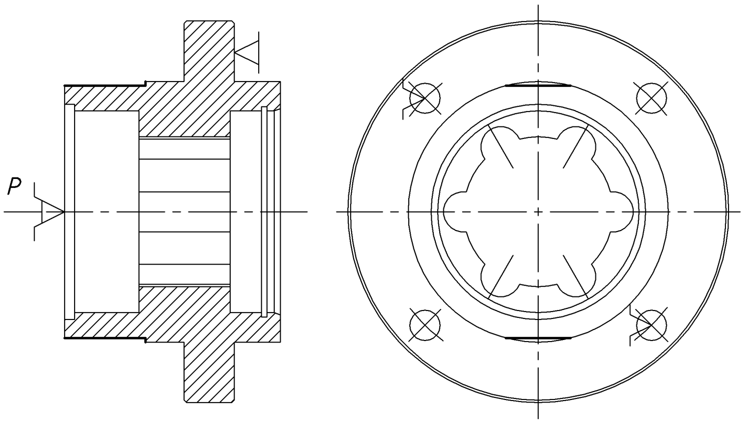
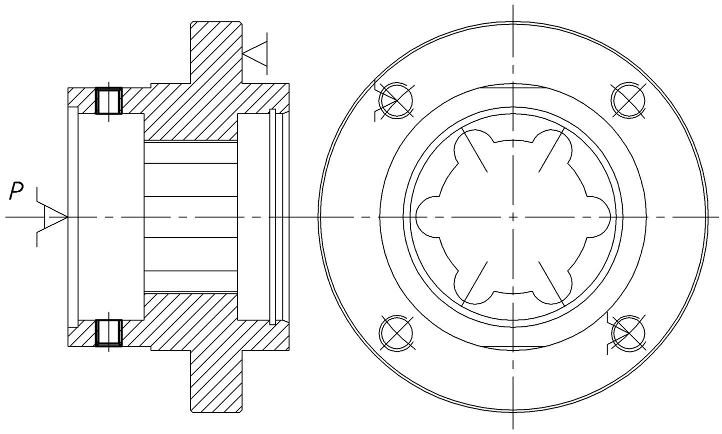
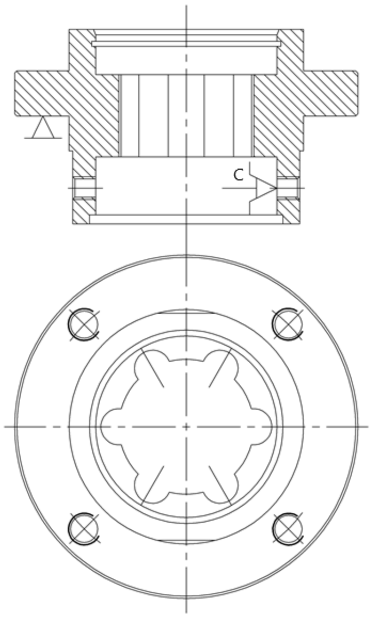
2.3 Selection of technological bases

The results of the choice of base schemes on the principle of combining bases - technological, measuring, installation, are summarized in table 2.3.

Table 2.3 - Schemes of basing and fixing the part

№ opera	The name of the operation	Scheme of basing
1	2	3
005	Turning	
010	Vertical drilling	

015	CNC milling	
020	Horizontally long	

025	Vertical milling	
030	Vertical drilling	
035	Vertical drilling	

2.4 Designing the technological route of machining parts

Consider different options for technological processes of machining of the product in order to choose the best. Routes of processing of technological processes are given accordingly in tables 2.4 and 2.5.

Table 2.4 - The first route of machining of the part

№ operations	The name of the operation, the transition	Processed surface	Base surfaces	Equipment mod.
1	2	3	4	5
005	Vertical drilling 1. Drill a hole beforehand	*Y*	*N, M*	2N135
010	Vertical drilling 1. Drill a hole	*Y*	*N, M*	2N135
015	CNC lathe 1. Trim the end 2. Sharpen the surface 3. Reinstall the part 4. Trim the end 5. Sharpen the surface 6. Sharpen the chamfer and groove 7. Sharpen chamfers	*A, G, V, P, M, I, L, K, N, O, U, Z, R*	*N, M, A, V*	16K30F3
020	CNC milling 1. Mill slots	*Y*	*G, P*	6R13F3
025	Horizontally long 1. Extend the slotted hole	*Y*	*G,P*	7B56

030	Vertical drilling 1. Drill 4 holes at a time	*F*	*V*, *Y*	2N135
035	Vertical drilling 1. To alternate 4 chamfers in turn 2. Change the tool 3. Cut alternately the thread in 4 holes.	*F, X*	*V*, *Y*	2N135
040	Vertical milling 1. Mill the shelf 2. Reinstall the part 3. Mill the shelf	H, H_1	*A, Y, I*	6N10
045	Radial drilling 1. Drill a hole 2. Reinstall the part 3. Drill a hole 4. Change the tool 5. Countersink the chamfer 6. Reinstall the part 7. Countersink the chamfer 8. Change the tool 9. Cut the thread 10. Reinstall the part 11. Cut the thread	D, E, D_1, E_1,	*A, Y, I*	2N55
050	Calibration 1. Calibrate the slotted hole	*R*	A, A_1	P6324
055	Screw-turning 1. Drill a hole	*G*, *Z*	*A, R*	16K20
060	Radial drilling 1. Calibrate the thread	*H*	*A, V*	2N55
065	Locksmith	All	—	—

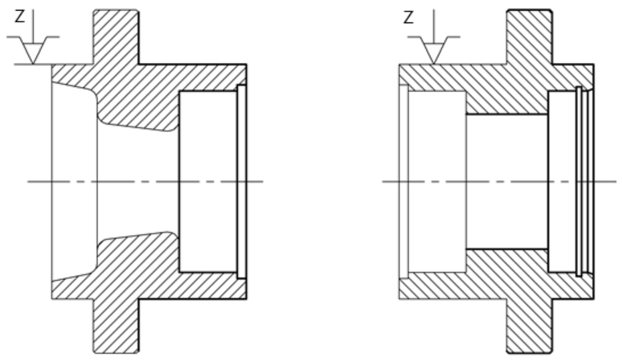
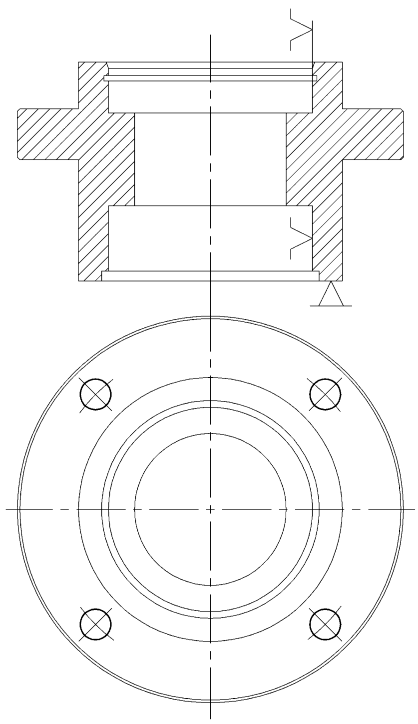
	1. Clean the burrs			
070	Flushing 1. Wash the part	All	—	2M2
075	Control 1. Check the dimensions	All	—	Pr1466

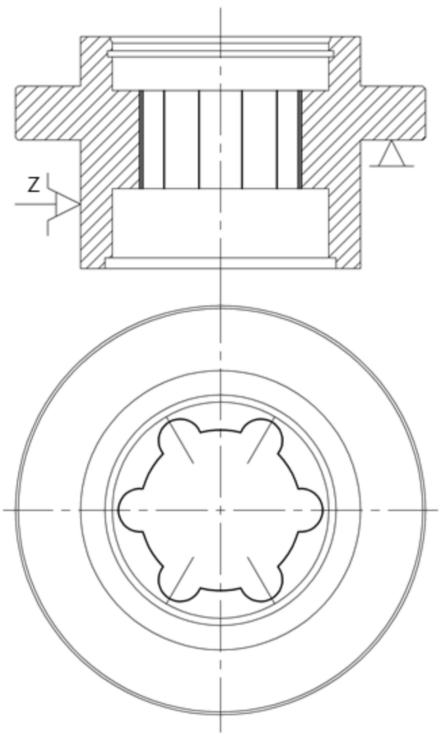
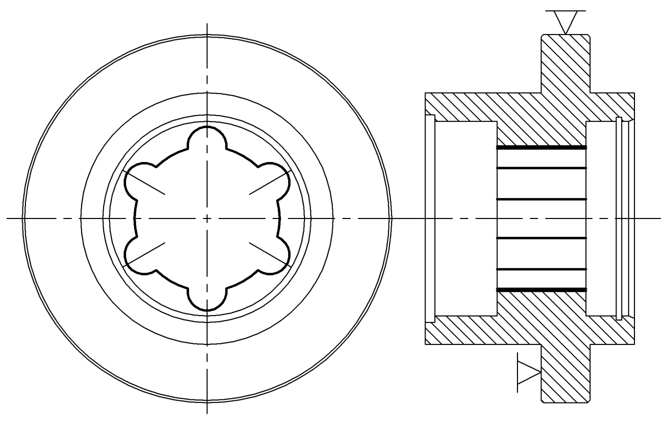
In the second variant of the technological process of manufacturing the flange, separate equipment was replaced by more advanced and the same type, which will increase productivity and reduce the cost of machining. In addition, operations 050 - calibration and 065 - radial drilling are not performed, as the quality and accuracy of the surfaces is ensured in previous machining operations.

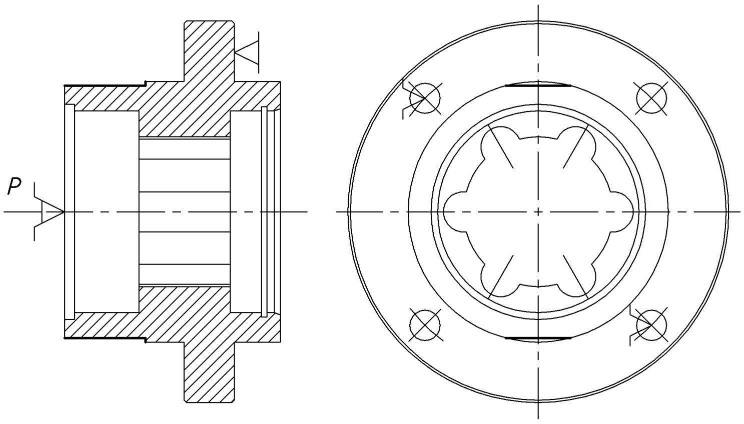
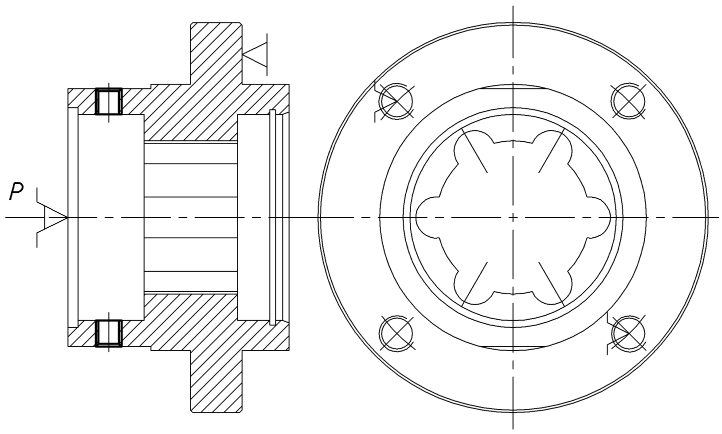
Therefore, for further development, we accept the second version of the technological process of manufacturing parts "flange 746.647.008".

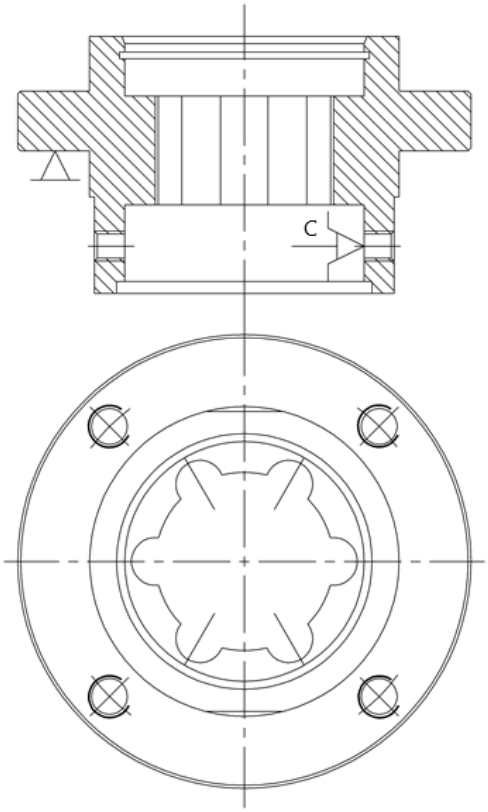
The results of the choice of base schemes on the principle of combining bases - technological, measuring, installation, are summarized in table 2.5.

Table 2.5 - Schemes of basing and fixing the part

№ oper.	The name of the operation	Basis scheme
1	2	3
005	Turning	
010	Vertical drilling	

015	CNC milling	
020	Horizontally long	

025	Vertical milling	
030	Vertical drilling	

035	Vertical drilling	

2.5 Determination of allowances for processing

The calculation of allowances for processing is carried out according to the recommendations [2, 10]. For clarity of this technique, we will calculate the allowances and inter-operational dimensions for the treatment of surfaces W, M in the size of 10+ 0.6 mm.

The technological route of processing of this surface consists of the following transitions:

1. Turning;
2. Clean turning.

We calculate the allowances for surface treatment.

For forging: Rz = 150 μm; T = 250 μm;

1. Turning: Rz = 30 microns; T = 30 μm;

2. Pure turning: Rz = 5 μm; T = 15 μm.

The total value of spatial deviations when basing the part

$$\rho_z = \sqrt{\rho_{kor}^2 + \rho_{cм}^2}\,, \qquad (2.8)$$

where Pkop- the amount of warping, microns;

Pcm - total offset, μm.

The magnitude of warping is equal

$$\rho_{kor} = \Delta_k l\,, \qquad (2.9)$$

where k is the specific curvature of the workpiece, k = 1.5 μm / mm;

l is the length of the workpiece, l = 140 mm.

$$\rho_{kor} = 1{,}5 \cdot 140 = 210 \text{ μm.}$$

The Total offset is equal

$$\rho_{cм} = \sqrt{\left(\frac{\delta_1}{2}\right)^2}\,, \qquad (2.10)$$

Where d1, is the tolerance on the size that determines the position of the base surface during processing , d1= 200μm.

$$\rho_{cм} = \sqrt{\left(\frac{200}{2}\right)^2} = 100 \text{ μm.}$$

$$\rho_з = \sqrt{210^2 + 100^2} \approx 233\text{μm.}$$

The magnitude of the residual spatial deviation after the transitions

$$\rho_1 = 0{,}05\rho_з = 0{,}05 \cdot 233 = 11{,}65 \approx 12\text{ μm.}$$

$$\rho_2 = 0{,}05\rho_1 = 0{,}05 \cdot 12 \approx 1\text{μm.}$$

The base error occurs due to the possible skew of the work-piece during the installation in the chuck. The maximum value of the gap is equal

$$S_{max} = \delta_A + \delta_B + s_{min}, \quad (2.11)$$

where A is the tolerance on the diameter of the mounting surface, A = 16 μm;
B - tolerance for the execution of the fastening element, B = 14 μm;
s_{min} - minimum gap, smin = 13 μm.

The maximum angle of rotation of the workpiece

$$tg\alpha = \frac{\delta_A + \delta_B + s_{min}}{L_c}, \quad (2.12)$$

where L is the linear length of the workpiece, L = 71 mm

$$tg\alpha = \frac{0{,}016 + 0{,}014 + 0{,}013}{71} \approx 0{,}0006.$$

Base error along the length of the workpiece surface

$$\varepsilon_b = l \cdot tg\alpha \quad (2.13)$$

$$\varepsilon_b = 140 \cdot 0{,}0005 = 0{,}07 \text{ mm} = 70\mu m;$$

The error of fixing the workpiece e, with = 40 μm [2]. Installation error when turning

$$\varepsilon_1 = \sqrt{\varepsilon_b^2 + \varepsilon_z^2}. \quad (2.14)$$

$$\varepsilon_1 = \sqrt{70^2 + 40^2} \approx 80 \ \mu m$$

Installation error at finishing turning

$$\varepsilon_2 = 0{,}05 \cdot \varepsilon_1. \quad (2.15)$$

$$\varepsilon_2 = 0{,}05 \cdot 80 \approx 4 \mu m$$

Minimum values of interoperative allowances [2]

$$2Z_{min} = 2(R_{Zi-1} + T_{i-1} + \rho_{i-1}). \quad (2.16)$$

Minimum processing allowance

$$2Z_{min1} = 2(150 + 250 + 246) = 2 \cdot 646 \mu m$$

$$2Z_{min2} = 2(30 + 30 + 12) = 2 \cdot 72 \mu m$$

The estimated size l, is determined starting from the final size by successively adding the estimated minimum allowance of each technological transition. For turning

$$l_{p1} = 10 + 0{,}146 = 10{,}146 \ \mu m$$

- for preparation

$$l_{p2} = 10{,}146 + 1{,}308 = 11{,}454 \ \mu m$$

The values of the size limits will be as follows:

- for finishing turning $l_{\min ZAG} = 9{,}8$ μm

$$l_{\max ZAG} = 9{,}8 + 0{,}2 = 10 \ \mu m$$

- for turning $l_{\min ZAG} = 10{,}15$ μm

$$l_{\max ZAG} = 10{,}15 + 0{,}25 = 10{,}4 \ \mu m$$

Minimum marginal values of allowances $2z_{\min}^{np}$ the difference equal to the smallest limit size of the executable and the previous size, and the maximum values $2z_{\max}^{np}$ differences of the largest limit sizes.

$$2z_{\min 2}^{np} = 10{,}15 - 9{,}8 = 0{,}35 \text{ mm} = 350 \ \mu m;$$

$$2z_{\max 2}^{np} = 10{,}4 - 10 = 0{,}4 \text{ mm} = 400 \ \mu m;$$

$$2z_{\min 1}^{np} = 11{,}45 - 10{,}15 = 1{,}3 \text{ mm} = 1300 \ \mu m;$$

$$2z_{\max 1}^{np} = 14{,}65 - 10{,}4 = 4{,}25 \text{ mm} = 4250 \ \mu m.$$

General allowances $z_{O\min}$ i $z_{O\max}$ is equal

$$2z_{0\min} = 350 + 1300 = 1650 \ \mu m;$$

$$2z_{0\max} = 400 + 4250 = 4650 \ \mu m.$$

Total nominal allowance

$$z_{0nom} = z_{0\min} + H_Z - H_D, \qquad (2.17)$$

where N_Z - lower deviation of the workpiece, μm;
N_D - lower deviation of the part, μm.

$$N_Z = U_i + \frac{K_y}{2}, \qquad (2.18)$$

Where U_i - tolerance for wear tool, U_i = 0.8 mm;

K_y - shrinkage oscillation, K_y = 1.0 μm/mm.

$$H_Z = 0,8 + \frac{1,0}{2} = 0,4 \text{ mm} = 400 \text{ мкм.}$$

$$z_{0nom} = 1650 + 400 - 200 = 1850 \text{ мкм.}$$

Nominal size of the workpiece

$$d_{Z\,nom} = d_{Dnom} + z_{onom} \text{ mm.} \qquad (2.19)$$

$$d_{Z\,nom} = 9,8 + 1,85 = 11,65 \text{ mm.}$$

We will check the correctness of calculated allowances and sizes

$$z^{np}_{\max 2} - z^{np}_{\min 2} = \delta_1 - \delta_2;$$

400 – 350 = 250 – 200;

50 = 50.

$$z^{np}_{\max 1} - z^{np}_{\min 1} = \delta_3 - \delta_2;$$

4250 – 1300 = 3200 – 250;

2950 = 2950.

- so the calculations were carried out correctly.

Table 2.7 - Calculation of allowances of limit sizes on technological transitions on processing of surfaces Zh, M in the size of 10 + 0,6 mm

Technological transitions of processing	Allowance elements. μm				Estimated allowance 2Zmin	Estimated size lp, mm	Tolerance, μm	Maximum size		Limit values of allowances, μm	
	R_z	T	ρ	ε				$l_{\min}$	$l_{\max}$	$2z^{np}_{\min}$	$2z^{np}_{\max}$
Procurement	150	250	246	–	–	11,454	3200	11,45	14,65		
1. Turning	30	30	12	141	2·646	10,146	250	10,15	10,4	1300	4250

2.Clean turning	5	15	1	7	2·72	10	200	9,8	10	350	400
										1650	4650

2.6 Calculation and selection of processing modes and technical time norms

Calculation of cutting modes is carried out by the calculation and analytical method and using regulatory data.

Operation 015 - vertical-milling

Cutting depth t = 10 mm; number of passes and = 6; number of teeth milling z = 12; milling width B = 20 mm; feed Sz = 0,15 mm/tooth [9].Cutting speed is determined according to recommendations [9]

Cutting speed is determined according to recommendations [9]

$$V = \frac{C_v \cdot D^q \cdot K_t \cdot K_n \cdot K_u \cdot K_f}{T^t \cdot t^x \cdot S^y \cdot z^n \cdot B^z}, \qquad (2.20)$$

where Cv is the constant coefficient, Cv = 64.7 [9];

D - mill diameter, D = 20 mm; q, m, x, y, n, z - exponents,

q = 0,25; m = 0,2; x = 0.15; y = 0,6; p = 0.1; z = 0,1 [9];

T - instrument stability period, T = 180 min. [9];

Kt, Kp, Ki, Kf - corrective coefficients, Kt = 1; Kp = 0.9; Ki = 1.3; Kf = 1 [9].

$$V = \frac{64{,}7 \cdot 20^{0{,}25} \cdot 1 \cdot 0{,}9 \cdot 1{,}3 \cdot 1}{180^{0{,}2} \cdot 2^{0{,}15} \cdot 0{,}08^{0{,}2} \cdot 12^{0{,}1} \cdot 39^{0{,}1}} = 17{,}7 \text{ m/min}$$

Spindle rotation number

$$n = \frac{1000 \cdot 17{,}7}{3{,}14 \cdot 20} = 282 \text{ rpm}$$

We adjust the estimated value of the rotation numbers with the passport data of the machine (mod.6N10) p = 250 rpm. Valid cutting speed

$$n = \frac{1000V}{\pi D}. \quad (2.27)$$

After the data is substituted, we will get

$$n = \frac{1000 \cdot 16{,}03}{3{,}14 \cdot 9} = 567{,}2 \approx 567 \text{ rpm.}$$

We adjust the estimated value of the rotation numbers with the passport data of the machine (mod.2C132) p = 500 rpm. Valid cutting speed

$$V = \frac{\pi Dn}{1000} = \frac{3{,}14 \cdot 9 \cdot 500}{1000} \approx 14{,}1 \text{ m/min.}$$

Cutting power efficiency [9]

$$N_e = \frac{M_K \cdot n}{975 \cdot 1000}, \quad (2.28)$$

where M_K - torque, N

$$M_K = C_m \cdot D^{2.0} \cdot S^y \cdot K_m, \quad (2.29)$$

where Cm - constant coefficient, Cm = 39 [9];

y - exponent, y = 0,8 [9];

Km - corrective coefficient, Km = 0,78 [9].

$$M_K = 39 \cdot 9^{2.0} \cdot 0{,}2^{0,8} \cdot 0{,}78 = 679{,}9 \approx 680 \text{ N·m.}$$

Effective cutting power

$$N_e = \frac{680 \cdot 500}{975 \cdot 1000} \approx 0{,}35 \text{ KWt.}$$

Main time

$$T_o = \frac{L}{n \cdot S}, \quad (2.30)$$

where L - the total cutting length, mm;

$$L = t + y_1 + y_2, \quad (2.31)$$

where y1 - the size of the tool, y1 = 3 mm;

y2 - the value of the instrument, y2 = 3 mm.

$$L = 10 + 3 + 3 = 16 \text{ mm.}$$

$$T_o = \frac{16}{500 \cdot 0{,}2} = 0{,}16 \text{ min.}$$

Calculations of cutting modes for other technological operations are carried out according to the recommendations of reference literature [9, 10] and the results are recorded in table 2.8.

Table 2.8 - Cutting modes for technological process operations

№ oper.	Operation Name and transition	L, mm	t, mm	i	S, mm/rpm	S_m, mm	n, rpm.	V, m/min	T_o, min	N, kWt
1	2	3	4	5	6	7	8	9	10	11
005	Turning									4,31
	Transition 1	52	2,5	1	0,45	-	250	103	1,59	
	Transition 2	30	4	2	0,4	-	200	94	2,65	
	Transition 4	52	2,5	1	0,45	-	250	103	1,59	
	Transition 5	20	4	2	0,4	-	200	94	3,04	
	Transition 6	2,3	2,3	1	0,2	-	200	93	0,42	
	Transition 7	36	8	3	0,45	-	250	103	1,06	
010	Vertical-drilling									
	Transition 1									0,35
		11	5,5	1	0,2	-	500	14,1	0,16	
015	Vertical-milling									
	Transition 1									1,45
		36	10	6	-	0,15	250	15,7	2,28	
020	Horizontal-extended									
	Transition 1									5,56
	Transition 3	1420	-	1	-	-	-	3	0,8	
		1420	-	1	-	-	-	3	0,8	
025	Vertical-milling									
	Transition 1									0,65
	Transition 3	20	1,6	1	-	0,15	250	15,7	0,62	
		20	1,6	1	-	0,15	250	15,7	0,62	
030	Vertical-drilling									
	Transition 1									0,31
	Transition 2	11	5,5	1	manual	-	710	8,9	0,6	
	Transition 3	3	1	1	manual	-	355	13,4	0,04	
	Transition 5	10	-	1	0,941	-	250	7,9	0,16	
	Transition 6	11	5,5	1	manual	-	710	8,9	0,6	
	Transition 7	3	1	1	manual	-	355	13,4	0,04	
		10	-	1	0,941	-	250	7,9	0,16	
035	Vertical-drilling									
	Transition 1									0,28

	Transition 2	3 12	1 -	4 4	manual 0,941	- -	355 250	13,4 7,9	0,95 2,04	
050	Locksmith									
055	Washing									
060	Acceptance control									

3 DESIGN PART

3.1 Description of the design of the device for machining

To ensure the attachment of the spray disk, 4 holes of 11 mm are used, which are located on the end surface of the part. To increase the productivity of processing, it is advisable to drill all the holes at once. The conductor and the corresponding drilling head are used for technological execution of these openings.

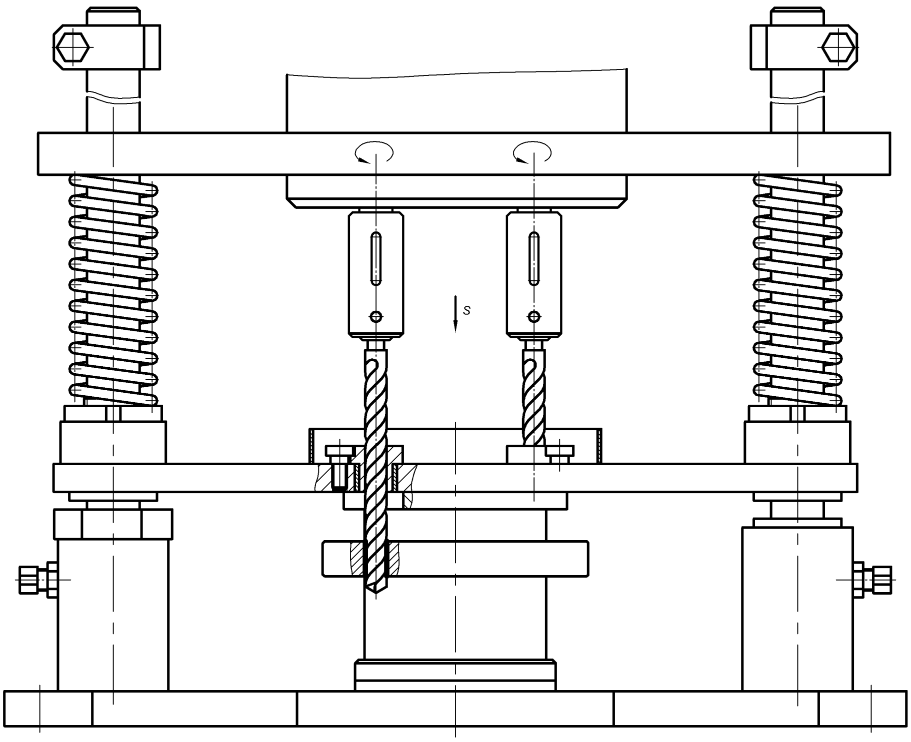


Figure 3.1 - Layout and base of the part in the conductor

This significantly increases the productivity and accuracy of drilling. The conductor consists of a plate on which racks with a conductor plate and other installation and executive elements are placed. The bases during machining are the internal holes of the flange, which the part is mounted on two cylindrical fingers, as well as the end surface. The clamp of the workpiece is provided by the vertical feed of the spindle with the drilling head and is transmitted through cylindrical springs to the conductor plate.

Mounting of the device on the machine table is carried out by means of 2 rim bolts and is fixed by mounting bolts through grooves of a plate of the case.

For machining by milling flat surfaces in the size of 100H12, you can use the device, the principle of operation and design of which are as follows. This device consists of a welded body on which other elements are mounted. The bases for the installation of the workpiece during machining are the end and cylindrical surfaces of the mounting sleeve. The clamping force is transmitted from the pneumatic cylinder through the rod and the clamping washer.

To carry out technological operations "clamp-expansion of a part" the pneumatic distributing crane which by means of pipelines is connected to the pneumatic cylinder is used. The supply of compressed air to the pneumatic cylinder is carried out from the pneumatic system. Mounting the device on the table. The machine is carried out by means of 2 keys and is fixed by assembly bolts through grooves on lateral parties of a plate of the case.

3.2. Calculation of device error

The following dependence can be used to calculate the manufacturing accuracy of the device [2]

$$\varepsilon_{pr} = \delta - k\sqrt{\left(k_1\varepsilon_b\right)^2 + \varepsilon_z^2 + \varepsilon_{yst}^2 + \varepsilon_{zn}^2 + \varepsilon_{r.i}^2 + \left(k_2\omega\right)^2}, \quad (3.1)$$

where δ - tolerance on the executive size, = 0.18 mm;

k is the coefficient that takes into account the possible deviation from the normal placement of individual components, k = 1,2;

ε_b is the basis error based on the following dependence [2]

$$\varepsilon_b = \frac{\delta_D}{2}, \quad (3.2)$$

Where δ_D--- admission to the mounting surface, δ_D = 0,16 mm;

$$\delta_D = 0{,}16 \text{ mm}; \varepsilon_б = \frac{0{,}16}{2} = 0{,}08 \text{ mm}.$$

k_1, k_2 – coefficients of serial production $k_1 = 0,7$; $k_2 = 0,6$;

$\varepsilon_з$ – error, taking into account the displacement of the machined surfaces of the workpiece due to the clamping force, $\varepsilon_з = 0$ mm;

$\varepsilon_{уст}$ – error of installation of the device on the machine, mm;

$$\varepsilon_{уст} = \frac{L_d \cdot s_w}{l}, \qquad (3.3)$$

where $L_д$ is the length of the treated surface, $L_d = 20$ mm;

s_w - the largest gap between the guide key of the device and the groove of the table, $s_w = 0,05$ mm;

l is the distance between the keys, $l = 390$ mm., $\varepsilon_{уст} = \frac{L_d \cdot s_w}{l}$ (3.3)

$$\varepsilon_{уст} = \frac{20 \cdot 0,05}{390} \approx 0,00128 \text{ mm.}$$

$\varepsilon_{zн}$ - wear error of the installation elements of the device, $\varepsilon_{zн} = 0,02$ mm;

$\varepsilon_{p.i}$ - error of displacement of the cutting tool, $\varepsilon_{p.i} = 0,1$;

ω - economic error for this method of processing, $\omega = 0,08$ mm.

Substitution of numerical values is obtained

$$\varepsilon_{np} = 0,18 - 1,2\sqrt{(0,7 \cdot 0,08)^2 + 0^2 + 0,00128^2 + 0,02^2 + 0,1^2 + (0,6 \cdot 0,08)^2} \approx 0,03 \text{ mm.}$$

$\varepsilon_{np} < \delta$ – therefore, the accuracy of processing is ensured.

The error of installation of the original workpiece in the device is due to a number of technological factors that determine the magnitude of the total error. To calculate the accuracy of the device, you can use the following dependence (3.1). Respectively $\delta = 0.36$ mm; k = 1.2; b = 0.18; k1 = 0.7; k2 = 0.6; c = 0.1 mm; $\varepsilon_{уст} = 0.041$ mm; $\varepsilon_{zн} = 0.04$ mm; $\varepsilon_{pi} = 0$; $\omega = 0.1$ mm.

Substitution of numerical values is obtained

$$\varepsilon_{np} = 0{,}36 - 1{,}2\sqrt{(0{,}7 \cdot 0{,}18)^2 + 0{,}1^2 + 0{,}041^2 + 0{,}04^2 + (0{,}6 \cdot 0{,}1)^2} \approx 0{,}142$$

- therefore the accuracy of processing is provided.

3.3. Calculation of the drive of the device

The scheme of placement and basing of the part in the device is shown in Figure 3.1. Accordingly, the clamping force acts on the normal to the workpiece surface and creates a force that prevents the displacement of the workpiece under the action of the cutting force.

The required clamping force P is determined from the following equation

$$P \geq mP_o, \tag{3.4}$$

where m is the number of simultaneously running tools;

P_o - axial cutting force.

$$P_o = 10C_p D^q s^y K_p, \tag{3.5}$$

where C_p is a constant coefficient C_p = 42.7 [10];

D is the diameter of the drill, D = 11 mm;

q, y - exponents, q = 1; y = 0.8 [10];

s - tool feed, s = 0.2 mm / rev. (see section 2.7);

K_p - coefficient that takes into account the actual processing conditions.

$$K_p = \left(\frac{HB}{190}\right)^n \quad , (3.6)$$

where HB - the value of the Brinell hardness of the material, HB = 150 (see section 1.1);

n --degree indicator, n=0,6[10]

$$K_p = \left(\frac{150}{190}\right)^{0,6} = 1{,}03$$

Axial cutting force

$$P_o = 10 \cdot 42{,}7 \cdot 11^1 \cdot 0{,}2^{0{,}8} \cdot 0{,}9 = 1272{,}5 \text{ N.}$$

Required clamping force

$$P \geq 4 \cdot 1272{,}5 = 5090 \text{ N}$$

We will check whether the selected equipment provides clamping force.

$$Ndv \geq N_{go} \eta_v , \quad (3.7)$$

where Ndv - engine power of the machine, Ndv = 7.5 kW (mod.2S132);
Ngo - power of the drilling head, kW;
nv is the efficiency of the machine, nv = 0.8 (for drilling) [10].

$$N_{hol} = m \cdot N \cdot \eta_{hol} , \quad (3.8)$$

where m is the number of tools, m = 4;
N - processing power of one tool, N 0.35 kW (see section 2.7);
η_{hol} - efficiency of the drilling head, $\eta_{гол}$ = 0.8… 0.9 [10].

$$N_{hol} = 4 \cdot 0{,}35 \cdot 0{,}85 = 1{,}19 \text{ kWt.}$$

$$7{,}5 \geq 1{,}19$$

- the condition is fulfilled, so the equipment is selected correctly and the clamping force is provided.

The scheme of placement and basing of the part in the device is shown in Figure 3.2. When milling a part with a face milling machine, the part is based on a mounting sleeve with a clamp in the end face. Accordingly, the clamping force acts on the normal to the workpiece surface and creates a force that prevents the displacement of the workpiece under the action of the cutting force.

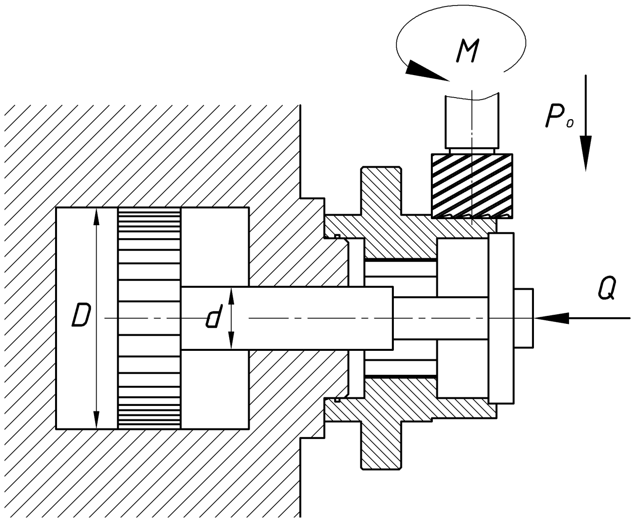


Figure 3.2 - Scheme of basing and clamping the part in the milling device

The required clamping force P is determined from the following equation

$$Ff + F_1 f + F_2 f \geq kP_{cut}, \quad (3.9)$$

where F, F1, F2 - components of friction forces;

f is the coefficient of friction at the point of contact of the workpiece and the mounting and clamping elements, f = 0,15;

P_{cut} - cutting force;

$$P_{cut} = C_p \cdot t^x \cdot S_z^y \cdot z \cdot B^z \cdot D^q \quad (3.10)$$

where Cr is a constant coefficient, Cr = 68 [9];

t - depth of cut, t = 1.62 mm;

Sz - feed, Sz = 0.08 mm / tooth. [9];

z is the number of teeth of the cutter, z = 12;

B - milling width, B = 32 mm;

D - diameter of the cutter, D = 40 mm;

q, x, y, z - exponents, q = - 0.86; x = 0.86; y = 0.74; z = 1 [9].

$$P_{cut} = 68 \cdot 1,62^{0,86} \cdot 0,08^{0,74} \cdot 12 \cdot 32^1 \cdot 40^{-0,86} = 70,5$$

k is the stock ratio.

The stock factor k can be represented as the product of the primary coefficients [9]

$$k = k_1 \cdot k_2 \cdot k_3 \cdot k_4 \cdot k_5 \cdot k_6, \qquad (3.11)$$

where k1 is the guaranteed stock ratio, k1 = 1.5;

k2 is the coefficient of change of the allowance for finished blanks, k2 = 1,0;

k3 - coefficient that takes into account the increase in cutting force when blunting the tool, k3 = 1,2;

k4 is the correction factor for continuous milling, k4 = 1.0;

k5 is the coefficient that takes into account the pneumatic clamping of the part, k5 = 1,0;

k6 is the correction factor for additional torques, k1 = 1.5.

Substituting the primary coefficients into equation (3.11) we obtain

$k = 1{,}5 \cdot 1{,}2 \cdot 1{,}0 \cdot 1{,}0 \cdot 1{,}0 \cdot 1{,}5 = 2{,}7$

The components of the friction forces can be expressed through the clamping forces

$$F = F_1 = F_2 = P, \qquad (3.12)$$

The relationship between the clamping force and the force of the pneumatic cylinder

$$P = Q, \qquad (3.13)$$

Accordingly, the equality to determine the clamping force will take the form

$$Q \cdot f = kP_{cut}. \qquad (3.14)$$

Where is the effort of the pneumatic cylinder

$$Q = \frac{kP_{cut}}{f}. \qquad (3.15)$$

By substituting numerical data into equation (3.15) we obtain

$$Q = \frac{2{,}7 \cdot 70{,}5}{0{,}15} = 1268 \text{ N}.$$

The calculation of the diameter of the pneumatic cylinder of the clamping device can be performed according to the following dependence

$$Q = \frac{\pi\left(D_P^2 - d^2\right)}{4} \cdot p\,, \tag{3.16}$$

where DP is the diameter of the pneumatic cylinder, cm;

d is the diameter of the rod of the pneumatic cylinder, d = 4 cm;

p - operating pressure in the pneumatic system, p = 10 kg / cm2.

In accordance

$$D = \sqrt{\frac{4Q}{\pi \cdot p} + d^2}\,. \tag{3.17}$$

Substituting numerical data we obtain

$$D = \sqrt{\frac{4 \cdot 1268}{3{,}14 \cdot 10} + 4^2} = 12{,}7 \text{ см} \approx 127 \text{ mm.}$$

From the standard values of the diameters of the pneumatic cylinders we take the diameter of the pneumatic cylinder D = 160 mm, the diameter of the rod d = 40 mm [10].

4 LIFE SAFETY, FUNDAMENTALS OF LABOR PROTECTION

4.1 Development of measures to reduce noise at the site

Protection against industrial noise is important for improving working conditions and increasing its productivity. There are many different means to reduce the noise from units and machines [11]. One of them is the replacement of the shock process by a shockless one. So the reciprocating motion of the parts of the units must be replaced by rotating. If there is noise from the vibration of impact parts and individual components, individual components must be treated with materials with high internal friction (rubber, cork, bitumen, felt).

Interleaving metal parts with plastic or other noise-free materials is also effective. With significant noise in the guide tubes (turret machines and others), it is advisable to arrange flexible connections between the rod and the tube, which are essentially damping devices that reduce vibration and noise.

Where there are fans, ejectors, blowers and other installations with air jets, it is necessary to make flexible transitions on air ducts from fabric, and flanges - from rubber. Significantly reduces the noise of lubrication of impact parts with viscous liquids. To reduce noise in the gearboxes, they are placed in liquid, oil and other baths. If it is not possible to reduce the noise at the source of its formation to an acceptable level, the unit design should include devices that prevent the spread of noise to the outside, ie insulate or absorb it.For units (electric motors, gear reducers, etc.) are placed in soundproof enclosures with outlet controls and controls and, if possible, to automatically control the operation of these units; noisy units of the unit - gear reducers, chain, belt and other transmissions, impact parts, engines, etc. - placed in insulating boxes and casings; the necessary openings in sound-insulating casings are made in the form of the channels lined from within with sound-absorbing materials; all units that create excessive noise due to vortex formation or exhaust of air and gases (fans, blowers, pneumatic tools, etc.), be equipped with special chambers.

With the right choice and installation of the fan, you can create a completely silent ventilation of industrial premises. Fans usually run at high speeds (up to 2000 rpm), which leads to significant vibrations. The noise of the ventilation unit spreads to neighboring rooms in three main ways: through ventilation ducts; through walls, windows or other fences; on a design of the room in the form of vibrations. To reduce the noise, it is necessary to choose low-noise fans if possible, install silencers in the air ducts, provide sufficient sound insulation of the ventilation chamber and the walls of the air ducts and, if necessary, vibration isolation of the unit.

Noise reduction can also be achieved by acoustic treatment of the room [11]. Acoustic treatment of the room involves covering the ceiling and upper walls with sound-absorbing material. As a result, the intensity of the reflected sound waves decreases. In addition to the ceiling, sound-absorbing boards, cones, cubes can be hung, resonator screens, ie artificial absorbers can be installed. The efficiency of acoustic treatment of premises depends on the sound-absorbing properties of materials and structures, their location, volume, geometry, location of noise sources. Measures to reduce noise should be provided at the design stage of industrial facilities and equipment. Particular attention should be paid to the removal of noisy equipment in a separate room, which reduces the number of employees in conditions of high noise and take measures to reduce noise with minimal costs, equipment and materials.

4.2 Measures for fire safety of the designed site

Prevention of the spread of fires is mainly determined by the fire safety of buildings and structures and is ensured by: the correct choice of the required degree of fire resistance of building structures; correct spatial planning decisions of buildings and structures; location of premises and productions taking into account fire safety requirements; installation of fire barriers in buildings, ventilation systems, fuel and cable communications; restriction of leakage and spreading of flammable liquids in case of fire; installation of smoke protection; design of evacuation routes; measures for the successful deployment of tactical actions to extinguish the fire.

When designing and building industrial enterprises, it is necessary to provide measures to prevent the spread of fire, namely [12]:

- division of the building by fire-fighting floors into fire compartments;
- division of the building by fire partitions into sections;
- installation of fire barriers to limit the spread of fire on structures, combustible materials (ridges, sides, belts);
- installation of fire doors and gates;
- arrangement of fire breaks between buildings.

For division of the building into fire compartments instead of fire walls fire zones which are carried out in the form of an insert on all width and height of the house are allowed. The insert is a part of the volume of the building, which is formed by fire walls (minimum fire resistance limit 0.75 hours). The width of the zone is not less than 12 m. Combustible substances are not allowed to be stored within the zone. Vertical diaphragms and water curtains are provided on the boundaries of the zone with fire compartments in accordance with SNiP 2.04.09-84 [12]. Within the zone, fire escapes are placed on the roof, and in the outer walls of the zone - doors or gates.

Holes in fire walls, partitions and ceilings must be equipped with protective devices (fire doors, fire doors, fire valves, water curtains) against the spread of fire and combustion products. It is not allowed to install any devices that interfere with the normal closing of fire and smoke doors, as well as to remove devices for their self-closing. When drawing up master plans of enterprises from the point of view of fire safety, it is important to ensure appropriate distances from the boundaries of enterprises to other enterprises and buildings. Fire-fighting distances between buildings must prevent the neighboring building from catching fire during the time required to activate the fire extinguisher.

Appropriate substances (plaster, special paints, varnishes, coatings) are used to protect metal, wood and polymer structures. Reducing the flammability of polymeric materials is achieved by introducing fillers, flame retardants, application of fire-retardant coatings. Chalk, kaolin, graphite, vermiculite, perlite, expanded clay are used as fillers. Flame retardants protect wood and polymers. When heated, they emit non-combustible substances, prevent the decomposition of wood and the release of flammable gases. After the expiration date and in case of loss or deterioration of fire-retardant properties, the treatment (impregnation) must be repeated.

CONCLUSIONS

In the qualification work of the bachelor in the general technical and technological part the analysis of technical requirements of the part "flange 746.647.008" and its official purpose is carried out. The analysis of the basic technological process of manufacturing the part was also carried out. The type of production established after the calculations is serial. Rational method of obtaining the workpiece - stamping. The technological process of flange manufacturing has been developed. It was also determined the allowances and interoperational dimensions, the choice of process equipment and cutting tools, as well as the calculation of cutting modes by operations. Also calculations of interoperative and intermediate allowances, modes of cutting on time norms are carried out.

As a result of the changes in the technological process, the reduction of artificial calculation time is ensured, as a result of the use of advanced equipment and equipment and combination of transitions, as well as the introduction of a rational method of obtaining the workpiece - stamping.

REFERENCES

1.Bozhenko LI Mechanical engineering technology. Design and manufacture of blanks. - Lviv: Svit, 1996. 368 p.

2.Gorbatsevich AF etc. Course design on mechanical engineering technology. - Minsk: Higher School, 1978. 288 p.

3. Grigurko IO, Brendulya MF, Dotsenko SM Technology of mechanical engineering. Diploma design: textbook. way. Lviv: New World, 2011. 768 p.

4.Kogut MS Mechanical assembly shops and sections in mechanical engineering. - Lviv .: Lviv Polytechnic State University Publishing House. 2000. 352 p.

5.Kapatsila Yu. B., Komar RV Design of machine-building industries: textbook. way. Ternopil: TNTU, 2017. 40 p ..

6. Bagrova IV Rationing of labor: textbook. way. Kyiv: Center for Educational Literature, 2003. 212 p.

7. Bialik OM, Chernenko VS, Pisarenko VM,. Moskalenko Yu. N. Metallurgy: textbook. Kyiv: Polytechnic, 2018. 384 p.

8.Pavlishte VT Fundamentals of design and calculation of machine parts. - К .: Вища школа, 1993. 556 с.

9. Modes of cutting metals: Handbook / Ed. Yu. V. Baranovsky. M .: Mashinostroenie, 1972. 409 s.

10. Handbook of machine-building technologist. In 2 volumes T2 / Ed. AG Kosilova and RK Meshcheryakov. 4th ed. rework and additional - M .: Mashinostroenie, 1986. - 496 p.

11. Pistun IP, Stets RE, Trunova IO Labor protection in the field of mechanical engineering: textbook. way. Sumy: University Book, 2011. 557 p.

12. Stitsenko TE, Pronyuk GV Serdyuk NM etc. Life safety: textbook. manual. Kharkiv: KhNURE, 2018. 336 p.

13. Дячун А.Є., Капацiла Ю.Б., Паливода Ю.Є., Ткаченко I.Г. Методичний посібник з виконання курсового проекту з дисципліни

«Технологія обробки типових деталей та складання машин». Тернопіль: ТНТУ, 2016. 75с.

14. Паливода Ю.Є., Дячун А.Є., Лещук Р.Я. Інструментальні матеріали, режими різання і технічне нормування механічної обробки : навчальний посібник. Тернопіль: Тернопільський національний технічний університет імені Івана Пулюя, 2019. 240 с.