МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
ТЕРНОПІЛЬСЬКИЙ НАЦІОНАЛЬНИЙ ТЕХНІЧНИЙ УНІВЕРСИТЕТ
ІМЕНІ ІВАНА ПУЛЮЯ

КАФЕДРА ТЕХНОЛОГІЇ МАШИНОБУДУВАННЯ

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МЕТОДИЧНІ ВКАЗІВКИ

до виконання курсової роботи з дисципліни

«ТЕХНОЛОГІЯ ОБРОБКИ ДЕТАЛЕЙ ТИСКОМ»

для здобувачів вищої освіти
з числа іноземних громадян
за спеціальністю 131 – «Прикладна механіка»

Тернопіль
2018

УДК 621.77
М54

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Методичний посібник розглянуто й затверджено на засіданні
кафедри технології машинобудування
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Протокол № 7 від 30 березня 2018 р.

Схвалено та рекомендовано до друку на засіданні методичної ради
факультету інженерії машин, споруд та технологій
Тернопільського національного технічного університету імені Івана Пулюя.
Протокол № 1 від 31 серпня 2018 р.

М54 Методичні вказівки до виконання курсового проекту з дисципліни «Технологія обробки деталей тиском» для здобувачів вищої освіти з числа іноземних громадян за спеціальністю 131 – «Прикладна механіка» / Укладачі : Радик Д.Л., Паньків М.Р., Паньків В.Р., Сіправська М.Д. – Тернопіль : Тернопільський національний технічний університет імені Івана Пулюя, 2018. – 44 с.

УДК 621.77

Відповідальна за випуск асистент *Сіправська М. Д.*

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

TERNOPIL NATIONAL TECHNICAL UNIVERSITY NAMED AFTER IVAN PUL'UJ

DEPARTMENT OF MANUFACTURING ENGINEERING TECHNOLOGIES

METHODICAL INSTRUCTIONS

to coursework from the discipline

“TECHNOLOGY OF WORKPIECE PRESSURE SHAPING”

for Mechanical Engineering major students

Ternopil
2018

УДК 621.77
М54

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Examined and approved at the methodological seminar of the manufacturing engineering department
Ternopil national technical university named after Ivan Pul'uj.
Protocol № 7 від 30 March 2018 г.

Recommended for publication by methodical commission of the faculty of engineering machinery, facilities and technologies,
Ternopil national technical university named after Ivan Pul'uj.
Protocol № 1 від 31 August 2018 г.

М54 Methodical instructions to coursework from the discipline "Technology of workpiece pressure shaping" for Mechanical Engineering major students/ Authors : Raduk. D.L., Pankiv M.R., Pankiv V.R., Sipravska M.D. – Ternopil : Ternopil national technical university named after Ivan Pul'uj, 2018. – 44 с.

УДК 621.77

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INTRODUCTION

In the general complex of technology of mechanical engineering acquired great significance such branch as the treatment of metals by pressure, which includes such operations as manual and machine forging, sheet and bulk stamping, pressing, rolling, drawing, etc.

The most progressive and widespread method of processing metals by pressure in modern mechanical engineering is stamping, which consists in plastic deformation of metal with the help of dies. Punching can be carried out both from a bulk billet by rolling, drawn or pressed rod (or thick band), and from sheet blanks - sheet material. The first process is called bulk stamping, and the second is sheet stamping.

In modern engineering, a significant part of products manufactured by punching. Sheet punching is a progressive type of material processing by pressure and using the sheet material as the initial blank (sheets, stripes, tapes), as well as technological transitions (punching, bending, pulling) allows us to produce a wide range of different types of flat and bulk products.

Sheet punching has a fairly wide application in all branches of machine and instrument making, metalworking, radio and electrical engineering. Preferably it is used in mass and batch production, as well as in small-scale, using universal punches.

The widespread use of sheet stamping techniques is provided by the following main advantages: high productivity and low cost of stamped parts; the possibility of manufacturing products with a minimum material capacity that can`t be provided by other methods of processing; high accuracy and quality of the surface of pressed parts, ensuring their interchangeability; relatively simple mechanization and automation of technological processes of sheet stamping; the possibility of obtaining products of complex form and configuration and high coefficient of material use; adaptability to scale of production.

Depending on the thickness of the sheet blank, the stamping is conventionally divided into thin-walled ($s < 4$ mm) and thick-sheeted ($s > 4$ mm), preforms with a thickness of 15-20 mm are generally stamped in hot form.

The range of sizes of stamped parts is quite large - in dimensions from a few millimeters to 6-7 m; in the thickness from a tenth of a millimeter to 100 mm or more. The precision of manufacturing parts is achieved with ordinary stamping grades 4-5, and with additional cleansing and calibration of grade 3-2 accuracy.

Typical content
Of explanatory note to the coursework
From subject
“TECHNOLOGY OF WORKPIECE PRESSURE SHAPING”
On the topic:
“Development of manufacture process of stamping a part …”

1. GENERAL PROVISIONS

The course work is carried out in order to consolidate the knowledge gained by students during theoretical study of the discipline "Technology of processing details by pressure" and acquiring practical skills during the technological preparation of production for sheet stamping, in particular in the selection of the workpiece and the determination of the coefficient of material use, the calculations of the power-supply parameters of the stamping process, the design of the stamp equipment, the choice of equipment and the development of stamping process .

When performing the course work, the following sections shall be developed:

- analysis of structural features of the part;
- choice of type of workpiece;
- determination of power-strength parameters of the stamping process;
- calculation and design of the stamp;
- equipment selection and its technical characteristics;
- development of the process of stamping.

The initial data for course work is an individual task for course work, drawing of the details, material and type of sheet metal.

Individual task students receive during practical classes at the beginning of the semester.

While performing the course work all explanations to the developed points of questions and calculations should be explained specifically with consistent, detailed explanations and references to literary sources and standards from which specific data are derived.

Coursework consists of a settlement and explanatory note and a graphic part.

The settlement and explanatory note for the course work should contain 25–30 printed sheets of the A4 format and have the following structural elements: title page, tasks for term paper (completed task form and work drawing details), calculation part (according to the points and sub-clauses of the typical content of the settlement- explanatory note to course work), conclusion, list of references, annexes (specification and technological documentation).

The volume of the graphic part in the course work should be 1–1,5 sheets of A1 format and contain a drawing of the stamp as well as working drawings of the matrix and punch, which simultaneously serve for cutting (punching).

2. RECOMMENDATIONS FOR CALCULATION AND EXPLANATORY NOTES

In the introduction to the course work must determine what is a sheet stamping, its advantages over other types of metal processing (technical, economic, constructive, technological). It is also necessary to indicate the areas of sheet stamping and its place and peculiarities in the general structure of machinery engineering. Specify in what types of production the most widely used sheet punching and why? For which details, this method of manufacture is the most acceptable.

1. Analysis of the structural features of the part

1.1. Purpose and characteristics of the part.

In this question, it is necessary to indicate where this item can be used, what it serves, what its functional purpose and which load can perceive. What type of attachment in the node of the unit of which it can be.

Next it is necessary to characterize the design features of the detail to which class it should be attributed. Describe the geometric details of the part, as well as do a conclusion on the most appropriate method of its manufacture.

Example: Detail "Shield" on the form refers to the flat parts and by the design is a plate, with overall dimensions of 50x100 mm and a thickness of 3 mm, with an inner hole with a diameter 12 mm. Since the material of the workpiece is a sheet of hot-rolled steel, Art. 3, this part should be made by punching, in particular cutting off by the outer contour and piercing the hole with a stamp.

1.2. Analysis of technical requirements and mechanical properties of material parts

In the question of the analysis of technical requirements it is necessary to analyze what requirements for accuracy of sizes (qualification of accuracy, accuracy tolerance on the sizes of surfaces) and surface roughness refer to this part. What surfaces can’t be processed, and those that are processed in the process of stamping need to analyze whether further mechanical treatment is needed, to give detailed information of the material details.

The mechanical properties of the material of the workpiece, from which the component is manufactured, can be taken from Annex 1 and presented in the form of Table 1:

Table 1 - Mechanical properties of the material of the part

$\sigma_т$ (σ_{02}), kgf /mm^2	$\sigma_в$, kgf /mm^2	σ_{cp} (τ_o), kgf /mm^2	δ		Ψ, %
			δ_5, %	δ_{10}, %	

where $\sigma_т$ (σ_{02}) – yield stress; $\sigma_в$ – tensile strength; σ_{cp} (τ_o) – shear resistance; δ – fineness ratio, in accordance δ_5 – at break of a short sample, length equal to five diameters, δ_{10} – at break of a long sample, the length is equal to ten diameters; Ψ – relative narrowing of the cut.

1.3. Analysis of the technological design of the detail

The technological processes of cold stamping can be the most rational only if the technological design or form of the part is created, which ensures its simplest and most economical production. Therefore, the processability of sheet-stamped parts is the most important prerequisite for the progressiveness of technological methods and cost-effectiveness of production.

Under the fabricability of stamped parts, should be understood as a set of properties and structural elements that provide the simplest and economical manufacturing of parts, subject to technical and operational requirements to them.

The operational and technical requirements for sheet stamped parts are mainly as follows:

- full compliance of the design with the purpose and conditions of operation of parts;
- providing the required durability and rigidity of the parts at a minimum metal outlet;
- providing the necessary accuracy and interchangeability;
- compliance with special physical, chemical or technical conditions.

Key indicators of manufacturability of sheet cold forged parts are:

- the smallest material dissipation;
- low labour input of operations;
- absence of subsequent machining;
- the smallest amount of necessary equipment and production space;
- the smallest amount of equipment with simultaneous reduction of costs and terms of preparation of production;
- increase of production productivity.

The general efficiency indicator of fabricability is the least cost of stamped parts.

Since the value and the ratio of the self-cost of products elements (material, wages, workshop discharges) depend on the seriality of production, then the concept of technology is inextricably linked with the type of production. Technological construction in the conditions of small-scale production may turn out to be non-technological in mass production and vice versa.

In most cases, the main criterion for the technological design of the component is the most economical material dissipation with the least number of operations and the reduction of labor intensity.

Basic technological requirements for the design of flat parts, obtained by cutting and punching.

1. It is necessary to avoid complicated configurations with narrow and long contour cutouts or very narrow cavities (b> 2 S), (Fig. 1).

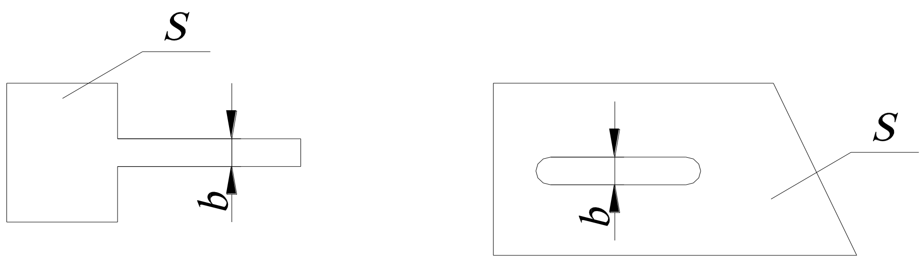


Figure 1 - Examples of parts configuration:
a) with a narrow and long cut; b) with a narrow slot

2. When punching (cutting off) in stamps with integral matrices conjugation in the corners of the inner contour of the parts should be performed with a radius of rounding r$\geq$0,5 S (Fig. 2).

In composite matrices, the conjugation of the sides perform without rounding (Figure 3)

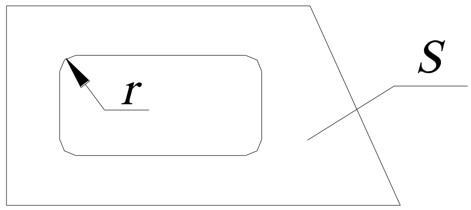


Figure 2 - An example of the configuration of a part with a pierced inner contour

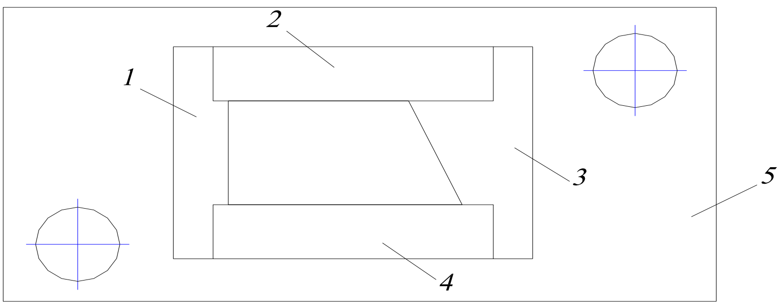


Figure 3 - Structure of the composite matrix:
1, 2, 3, 4 – parts of the matrix; 5 – matrix holder

3. Concussion of the sides of the outer contour should be done with rounding only during cutting out of the part over the entire circuit. In case of possible application of non-waste cutting should on the contrary, to admit and perform conjugation of the parties at right angles.

4. The smallest sizes of breakthrough openings should be selected according to tabular data of Table. 2

Table 2 - The smallest sizes of breakthrough openings

Material	Normal puncture with a free punch		Punching in a clamped state with a directional punch	
	Round	Rectangular	Round	Rectangular
Solid steel	1,3 *S*	1,0 *S*	0,50 *S*	0,40 *S*
Soft steel and brass	1,0 *S*	0,7 *S*	0,35 *S*	0,30 *S*
Aluminum	0,8 *S*	0,5 *S*	0,30 *S*	0,28 *S*

5. The smallest distance from the edge of the hole to the rectilinear outer contour must be not less than S for figured round holes and not less than 1,5 S if the edges of the hole are parallel to the contour of the part (Fig. 4).

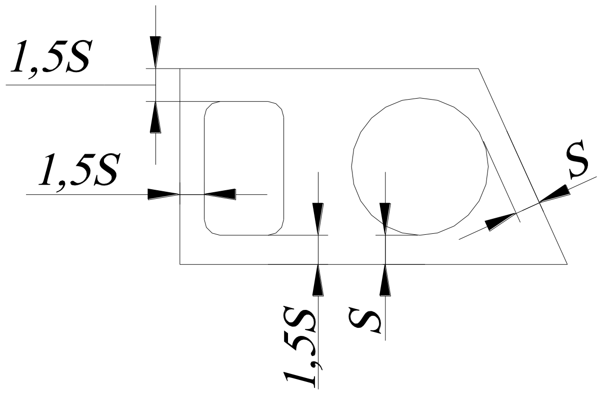


Figure 4 - The layout of the arrangement of round and rectilinear holes relative to the external contour of the part, when cutting (punching)

6. The smallest distance between the openings while simultaneously punching them should be in = (2 ÷3) S (Fig. 5)

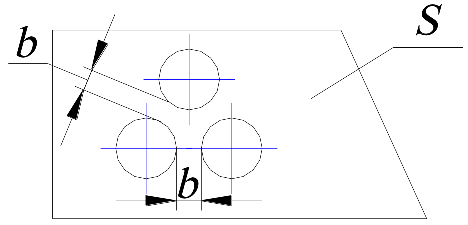


Figure 5 - An example of the arrangement of the holes on the detail, which at the same time break through

2. Choice of workpiece

2.1. Development of the material cutting scheme

The cutting out scheme of the material during sheet stamping is called the method of arrangement of cut pieces on the preform (sheet, strip, tape). In stamp production, material savings are largely determined by the cutting, it means the most rational placement of parts on the workpiece. The choice of the method of cutting the material largely depends on the design and dimensions of the stamped part.

Cutting of round parts can be done in one, two and several rows with their parallel and chess placement. Rounded parts with a diameter of more than 150 mm are usually cut in one row, with smaller sizes it is more economical to punch in several rows in a chess placement.

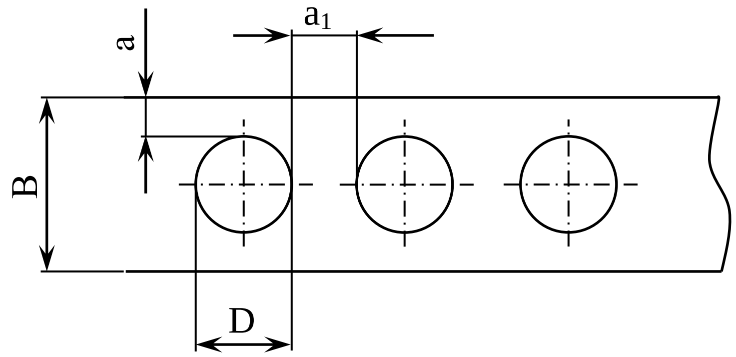
When cutting off rectangular and figured parts, the following types of cutting are used: straight, inclined, facing straight and facing inclined, combined, multi-row, with cut-off jumpers.

In addition, by the method of cutting, cutting out scheme ca be with jumpers and without jumpers. In the latter case, stamping is called low-waste or non-waste.

This point of the course work involves the development of an optimal scheme for cutting sheet into strips or parts to ensure the required number of products. Designing cutting out scheme cutting sheet material is necessary to minimize the amount of material waste. The results of the development presented in the form of graphical schemes of cutting the sheet or strip. Also, calculate the number of strips received from one sheet, the number of parts received from one lane and the total number of parts obtained from the sheet.

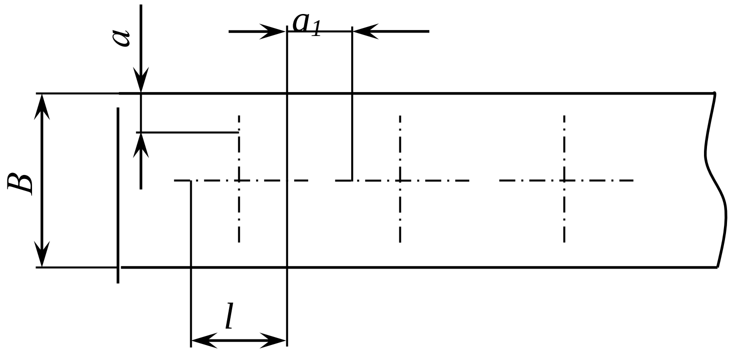
For a graphic representation of the cut-out scheme, it is necessary to represent in a scale several details (depending on the stamping method), taking into account the gaps between the part and the workpiece edge (a), between the adjacent parts (a1) and the step (K) when stamping this part.

Table 3.1 – The values of barriers *a* and a_1 recommended for parts with round shape for pattern cutting on sheet material



Material thickness S, mm	Part size D, mm							
	Less than 50		50 – 100		100 – 200		200 – 300	
	a_1	**a**	**a_1**	**a**	**a_1**	**a**	**a_1**	**a**
Less than 0,2	1,5	2,0	1,7	2,2	2,0	2,5	2,2	2,8
0,2 – 0,5	1,2	1,5	1,4	1,7	1,6	1,9	1,8	2,2
« 0,5 « 1,0	0,8	1,2	1,0	1,4	1,2	1,6	1,4	1,8
« 1,0 « 1,5	1,1	1,5	1,3	1,7	1,5	1,9	1,7	2,1
« 1,5 « 2,0	1,5	1,9	1,7	2,1	1,9	2,3	2,1	2,5
« 2,0 « 2,5	1,8	2,3	2,0	2,5	2,2	2,7	2,4	2,9
« 2,5 « 3,0	2,1	2,6	2,3	2,8	2,5	3,0	2,7	3,2
« 3,0 « 3,5	2,5	3,0	2,7	3,2	2,9	3,4	3,1	3,6
« 3,5 « 4,0	2,6	3,3	3,0	3,5	3,2	3,7	3,4	3,9
« 4,0 « 5,0	3,1	3,6	3,3	3,8	3,5	4,0	3,7	4,2
« 5,0 « 6,0	3,5	4,2	3,9	4,5	4,2	4,8	4,5	5,0
« 6,0 « 7,0	3,6	4,5	4,0	5,0	4,5	5,5	4,8	5,5
« 7,0 « 8,0	4,2	5,0	4,5	5,5	4,8	5,8	5,0	6,0
« 8,0 « 9,0	4,5	5,5	5,0	6,0	5,2	6,3	5,5	6,5
« 9,0 « 10,0	5,0	6,0	6,0	7,0	6,5	7,5	7,0	8,0

Table 3.2 – The values of barriers *a* and a_1 recommended for parts with square shape for pattern cutting on sheet material.

Material thickness S, mm								
	Part size *l*, mm							
	Less than 50		50 – 100		100 – 200		200 – 300	
	a_1	*a*	a_1	*a*	a_1	*a*	a_1	*a*
Less than 0,2	2,0	2,5	2,5	3,0	3,0	3,5	3,5	4,0
0,2 – 0,5	1,5	1,8	1,7	2,0	2,2	2,5	2,7	3,0
« 0,5 « 1,0	1,0	1,5	1,2	1,7	1,7	2,2	2,2	2,7
« 1,0 « 1,5	1,4	1,9	1,6	2,1	2,1	2,6	2,6	3,1
« 1,5 « 2,0	1,7	2,2	1,9	2,4	2,5	3,0	2,9	3,4
« 2,0 « 2,5	2,2	2,6	2,4	2,8	2,9	3,3	3,4	3,8
« 2,5 « 3,0	2,5	3,0	2,7	3,2	3,2	3,7	3,7	4,2
« 3,0 « 3,5	2,9	3,4	3,1	3,6	3,6	4,1	4,1	4,6
« 3,5 « 4,0	3,2	3,7	3,4	3,9	3,9	4,4	4,4	4,9
« 4,0 « 5,0	3,6	4,0	3,8	4,2	4,3	4,7	4,8	5,2
« 5,0 « 6,0	4,0	4,5	4,5	5,0	5,0	5,5	5,5	6,0
« 6,0 « 7,0	4,5	5,0	5,0	5,5	5,5	6,0	6,0	6,5
« 7,0 « 8,0	4,8	5,3	5,5	6,5	6,0	7,0	6,8	7,8
« 8,0 « 9,0	5,3	5,8	6,0	7,0	6,5	7,5	7,0	8,0
« 9,0 « 10,0	5,8	6,3	6,5	7,5	7,0	8,0	7,5	8,5

2.2. Choice of sheet metal

When elaborating this subparagraph, determine the type of workpiece based on the task for the course work. The material, according to the type of workpiece, is divided into sheets, stripes, tapes (rolls).

Recommended sizes of sheets: 710×1420, 1000×2000, 1250×2500, 1500×3000, 2000×5000 mm.

2.3. Calculation of material use coefficient

The indicator which characterizes efficiency of pattern cutting is the coefficient of material use (η), which is the ratio of the useful area of the part (F_o) to the area of the workpiece ($F_з$).

For the manufacture of one part when cutting from the piece workpiece (cassette), the coefficient of material use is determined by the formula (1).

$$\eta_1 = \frac{F_0}{F_з} \cdot 100\% , \tag{1}$$

The rationality of using the strip area (tape) is determined by the formula (2)

$$\eta = \frac{F_{01} \times n}{F_з} \cdot 100\% , \tag{2}$$

where F_{01} – area of one part(detail), mm;
$F_з = B \times L$ – tape area, mm;
n – number of parts in one tape;
B, L – tape length and width, mm.

The coefficient of the material use of the entire sheet is determined by the formula (3)

$$\eta_л = \frac{N_д F_{01}}{F_л} \cdot 100\% , \tag{3}$$

where $N_д$ – total number of parts received from the sheet, pcs;
F_{01} – area of one part, mm^2;
$F_л$ – sheet area, mm^2.

3. Determination of energy-power parameters of stamping process

3.1. Calculation of cutting force (punching)

The effort required to overcome the cut resistance of the metal at cutting (punching) in stamps, depends on several factors.

1. Factors related to material, shape and part dimensions: the mechanical properties of the metal and the depth of punch penetration into the metal; the thickness of the sheet material from which part is cut down; shape and size of harvested circuit.

2. Factors related to the stamp design include: the size of the gap between the die and punch, die design (hole shape for output parts or waste).

3. Cutting (punching) terms: deformation speed; lubrication of material and tools; shape of cutting edges of the punch and die, which may be flat, i.e. parallel and oblique – inclined to each other; wear state and the hardness of the blades.

Calculated effort in the process of cutting in stamps with parallel cutting blades when the angle $\varphi = 0°$, and cutting angle is $\delta = 90°$, is determined by the formula:

$$P = F_o\, \sigma_{зр} = u\, s\, \sigma_{зр}, \qquad (4)$$

where – $F_o = us$ – cutting area, mm^2;

u – contour length (perimeter) of cutted parts or holes that punching, mm^2;

s – the thickness of the sheet material, mm;

$\sigma_{зр}$ – cutting resistance (table value), kg/mm^2.

The actual cutting efforts in terms of production, taking into account factors are listed will be greater than estimated. Its value can be found using the coefficients that take into account the effect of each factor on the desired size. Total coefficient k, which is the sum of individual coefficients, that studies have shown, are in the range 1.0 – 1.3. Then the real value of cutting force (punching) Rd, which is taken as the initial value when calculating the power to choose the equipment will be equal

$$P_{\partial} = k\, P = k\, u\, s\, \sigma_{зр}. \qquad (5)$$

In the case where the manufacture of parts takes place in several transitions(operations), in this case it is necessary to calculate the cutting effort on each of them. The total (maximum) stamping effort is found as the sum of stamping effort at each of the transitions.

$$P_{\max} = P_{p1} + P_{p2} + ... + P_{pn}\,. \qquad (6)$$

3.2. Determination of part push effort (removal).

a) In sheet punching pushing force depends mainly on the same factors as cutting efforts, that is why in practice to simplify calculation of push efforts of product through the matrix (Q_{np}) taken to determine the percentage of cutting efforts. Thus a pushing force of parts given by

$$Q_{пр} = k_{пр} P, \tag{7}$$

where $k_{пр}$ – coefficient that taking into account the impact of various factors on push efforts similarly to the cutting effort.

The value of the coefficient can be selected from the table. 4

Table 4 – coefficient meaning

Material	Material thickness 0,5 – 10 mm
Steel	0,03 – 0,07
Copper and brass	0,02 – 0,04
Aluminum	0,03 – 0,05
duralumin	0,03 – 0,07

For thinner materials, the value $k_{пр}$ should be taken closer to the upper limit and for thicker ones – closer to the lower limit. For small gaps (from 5% S and less) $Q_{пр}$ rise in 1.5-2.5 times; and for high gaps (over 20% S) $Q_{пр}$ approaches zero. In the presence of lubrication, the push force can be reduced by 20 – 40%.

The actual pushing force will depend from number of parts n, which are simultaneously in the matrix hole.

If in a matrix the cylindrical belt has a height h, then in it can simultaneously be the number of parts equal:

$$n = \frac{h}{S},$$

where h is the height of the cylindrical belt of the matrix (selected constructively), mm;

s – thickness of the part, mm;

In this case pushing effort will be equal:

$$Q_{пр} = k_{пр} P\, n, \tag{8}$$

b) Removal effort of material from the punch ($Q_{зн}$) depends mainly from the same factors that push effort (with the exception of the shape of the matrix passage hole). In addition, when removing material from a punch, the size of the jumper has a significant effect (a) and the bend of the strip, which serves as a workpiece.

Removal efforts of material from the punch also determined by empirical relationships

$$Q_{зн} = k_{зн} P, \tag{9}$$

where $k_{зн}$ – coefficient that taking into account the impact of various factors on removal effort of material from punch.

The value of $k_{зн}$, depending on the size of the jumper during the cutting of parts from the strip, and also for the punching holes in the detail are given in Table. 5

Table 5 – coefficient meaning $k_{зн}$

Material	Waste removing	Part removing					
	Part punching from tape	Hole punching in part					Punching of several holes
		relation *a*/*b* *					
		Up to 0,5	0,5÷1	1÷1,5	1,5÷2	more 2	
Steel	0,03	0,04	0,045	0,05	0,06	0,07	0,07
Brass, copper, zinc	0,02	0,03	0,035	0,04	0,05	0,06	0,06
aluminum, duralumin	0,025	0,045	0,05	0,06	0,07	0,08	0,08

* where *a* – gap value;

b – dimension of the hole that is punching.

The overall stamping effort required determine the work that is spent on cutting (punching) and equipment selection is determined by the formula

$$P_{заг} = P_{max} + Q_{пр} + Q_{зн}, \qquad (10)$$

3.3. Calculation of spent work on stamping and power of the press

Work that is spent on cutting (punching), determined by the formula

$$A = \frac{\lambda \cdot P_{заг} \cdot S}{1000}, \text{Дж} \qquad (11)$$

where λ – coefficient expressing the ratio of average to maximum punching effort.

With a degree of accuracy sufficient for practice, the coefficient λ can be chosen depending on the thickness of the material S from the table. 6

Table 6 – The value of the coefficient λ for determining the work involved in stamping

Material thickness S, mm	Coefficien *λ*
Less than 2	0,75 – 0,55
From 2 to 4	0,55 – 0,45
More than 4	0,45 – 0,30

It should be noted that for soft and subtler materials it is necessary to take the value of the coefficient λ closer to the upper boundary, and for the solids and thicker ones, the values are closer to the lower bound.

Knowing the amount of work A spent on the operation of cutting (punching), you can find, in known formulas, the required power of the press and electric motor.

Example. It is necessary to determine the effort and the work to be done to punch the part in the form of a rectangular plate (Fig. 7) with dimensions b = 120 mm, c = 40 mm of steel of the Ct3 with a thickness of 2.2 mm on a die, in which the angle of inclination of the cutting blades of the matrix is φ = 0°.

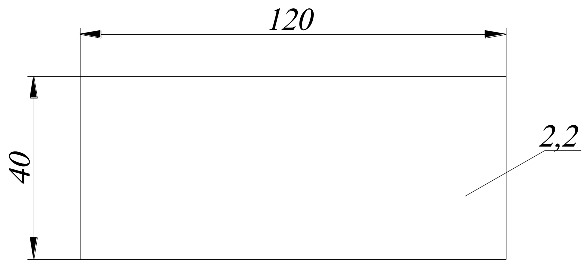


Figure 7 - Drawing details to determine the effort and the work involved in punching

For this brand of steel Ct3, $\sigma_{зр}$ = 350 mn/m^2 (35kg/mm^2) tab 4 annex 1.

Then the cutting efforts with normal operating conditions

$$P = u\, s\, \sigma_{зр} = 2\,(b + c)\, s\, \sigma_{зр} = 2\,(120 + 40) \times 2{,}2 \times \cdot 35 = 246400\ N$$

The real effort, for the choice of equipment, with the coefficient of correction k = 1,3

$$P_{д} = k \times P = 1{,}3 \cdot \times\ 24640 = 320320\ H \approx 320\ кN$$

Spent work on cutting at λ = 0,55

$$A = \frac{\lambda \cdot P_{ЗР} \cdot S}{1000} = \frac{0{,}55 \cdot 24640 \cdot 2{,}2}{1000} = 30 kg \cdot м (300 J)$$

4. Stamp calculation and designing

4.1. Stamp pressure center determining

For stamp correct work it is necessary to combine pressure center with slider axis, that is provided by shank placement in stamp top plate in such a manner so its axis pass through the stamp pressure center. In other case band torque appears, as a result skewed of slide take place which leads to rapid wear of the stamp guide.

In practice there are two methods for stamp pressure center determining:

1) Analytical – method of deformation resistance moments;

2) graphical method.

In regular geometric shapes (contours) pressure centers coincide with their geometric center, so the pressure center of this contours is not required for additional calculations, and just use the known geometric equations. Example, for round contour pressure center will be on the center of the circle, for line – on the middle of it, for rectangular contours – at the intersection of the diagonals, etc.

In the complex contour coordinates of pressure center determine by static torque applied to harvested perimeter contour, which is divided into a number of elementary sections. After determining the center of all the plots resultant point of application are finding out.

Analytical method is as follows. Let we need to punch two holes with diameters D_1, D_2 (Fig. 8). At first we have to find the punching effort for each hole. The point of application of resultant force P of forces P_1 and P_2 will be defining pressure center O. To establish a point of resultant force P will make a balance equation, for example relative to the point O_1 relatively unknown quantity x:

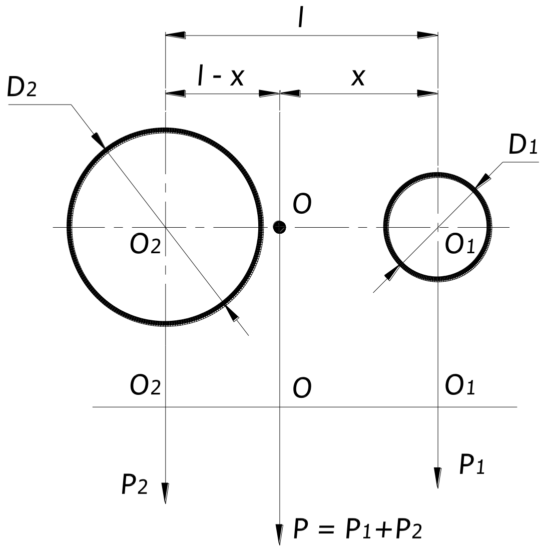


Figure 8 – Scheme for stamp pressure center determining with symmetrically placed holes

$$P_2 l = (P_1 + P_2) x,$$

where
$$x = \frac{P_2 l}{P_1 + P_2}, \tag{12}$$

or based on punching effort values P_{p1} i P_{p2}:

$$x = \frac{k u_2 s \tau_o l}{k(u_1 + u_2) s \tau_o} = \frac{u_2 l}{u_1 + u_2} = \frac{\pi D_2 l}{\pi(D_1 + D_2)} = \frac{\pi D_2 l}{D_1 + D_2} \tag{13}$$

That is, for practical determination of stamp pressure center position is enough to know the linear dimensions of punches and their relative positions.

In case of simultaneous cutting of dissimilar holes randomly located relative to both axes (Fig. 9) coordinates of stamp pressure center are determined by the equation:

$$x = \frac{P_1 x_1 + P_2 x_2 + P_3 x_3 + ... + P_n x_n}{P_1 + P_2 + P_3 + ... + P_n}; \tag{14}$$

$$y = \frac{P_1 y_1 + P_2 y_2 + P_3 y_3 + ... + P_n y_n}{P_1 + P_2 + P_3 + ... + P_n}. \tag{15}$$

Expressing these formulas through the length (perimeter) of harvested contours we will get:

$$x = \frac{u_1 x_1 + u_2 x_2 + u_3 x_3 + ... + u_n x_n}{u_1 + u_2 + u_3 + ... + u_n}; \tag{16}$$

$$y = \frac{u_1 y_1 + u_2 y_2 + u_3 y_3 + ... + u_n y_n}{u_1 + u_2 + u_3 + ... + u_n}. \qquad (17)$$

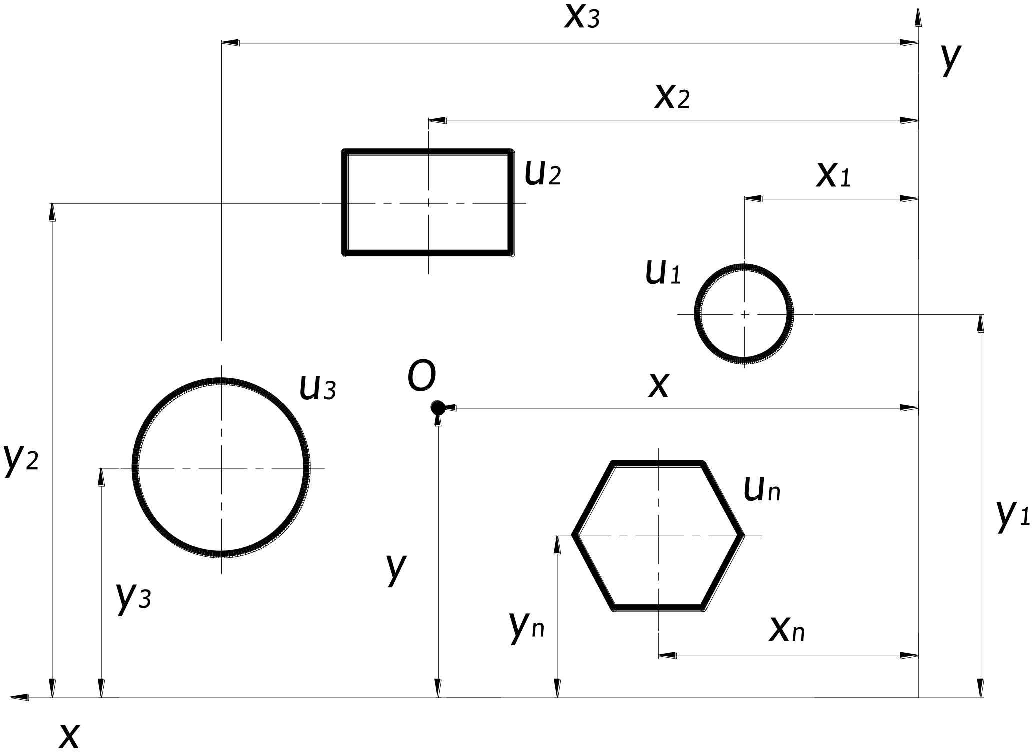


Figure 9 – Scheme for stamp pressure center determining with holes randomly placed relative to both coordinate axes

Example: It is necessary to determine the pressure center when punching the contour (Fig. 1).

1. At an arbitrary distance from the contour, we construct a rectangular coordinate system XY (Fig. 11).
2. 2. The perimeter (contour) of the details is divided into elementary areas l_1, l_2, ..., l_8 and we determine their centers of gravity.

In rectilinear areas, centers of gravity are placed in the middle of the segments. Centers for the arcs weight of circles with radius R_1=30mm, and R_2=40mm located on axes of symmetry of arcs AB and CD, and their distance from the centers of radius C1 and C2 according to the statics of solids bodies, is determined by the formula:

$$C = \frac{2\sqrt{2} \cdot R}{\pi} \approx 0{,}9 \cdot R$$

Where R_1=30 mm , C_1=27 mm; при R_1=40 mm , C_1=36 mm.

To determine the center of gravity of the considered arcs relatively to the axes X and Y, it is necessary to find the auxiliary sizes a1, b1, a2, b2 as cathetus of rectangular triangles (Fig. 11).

3. In accordance with the drawing of the part, we determine the coordinates of the pressure centers of all elementary areas relative to the coordinate axes. Before, we take the distances of the outer sides (or angles) of the contour to the coordinate axes equal to 20mm.

4. Determine the coordinates of the pressure center of the entire contour according to the formulas:

relative to the Y axis:

$$X_0 = \frac{l_1 \cdot X_1 + l_2 \cdot X_2 + \ldots + l_n \cdot X_n}{l_1 + l_2 + \ldots + l_n}; \qquad (18)$$

relative to the X axis:

$$Y_0 = \frac{l_1 \cdot Y_1 + l_2 \cdot Y_2 + \ldots + l_n \cdot Y_n}{l_1 + l_2 + \ldots + l_n}, \qquad (19)$$

where, X_1, X_2, ... X_n – abscissa of centers of weight of elements of a contour;
Y_1, Y_2, ... Y_n – ordinates of centers of weight of contour elements.

The length of the elementary areas of the contour is based on the dimensions of the drawing of the part:

$$l_1 = \sqrt{10^2 + 40^2} \approx 41mm; \quad l_2 = 180 - 30 = 150mm; \quad l_3 = \frac{2 \cdot \pi \cdot 30}{4} = 47mm$$

$$l_4 = 80 - 30 - 20 = 30mm \quad l_5 = \sqrt{20^2 + 40^2} = 45mm$$

$$l_6 = 180 - 40 - 40 - 40 - 10 = 50mm; \quad l_7 = \frac{2 \cdot \pi \cdot 40}{4} = 63mm \; l_8 = 40mm.$$

After substitution of the found values in the formulas 18, 19 we obtain:

$$X_0 = \frac{41 \cdot 195 + 150 \cdot 125 + 47 \cdot 31 + 30 \cdot 20 + 45 \cdot 40 + 50 \cdot 85 + 63 \cdot 124{,}5 + 40 \cdot 170}{466} = \frac{49496}{466} = 106mm$$

$$Y_0 = \frac{41 \cdot 40 + 150 \cdot 20 + 47 \cdot 31 + 30 \cdot 65 + 45 \cdot 90 + 50 \cdot 100 + 63 \cdot 74{,}5 + 40 \cdot 60}{466} = \frac{21190}{466} = 52mm;$$

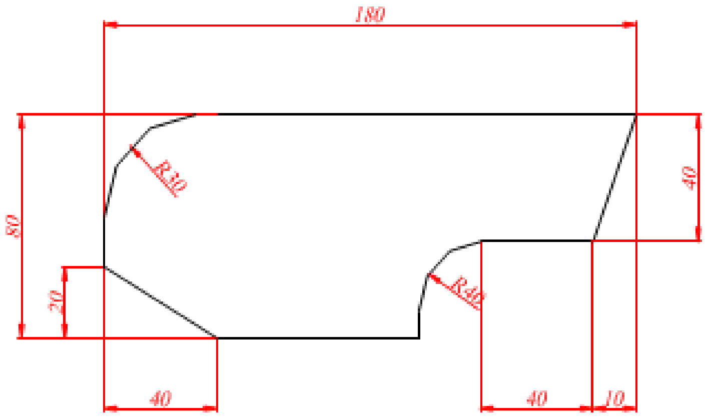


Fig 1. Drawing of the detail

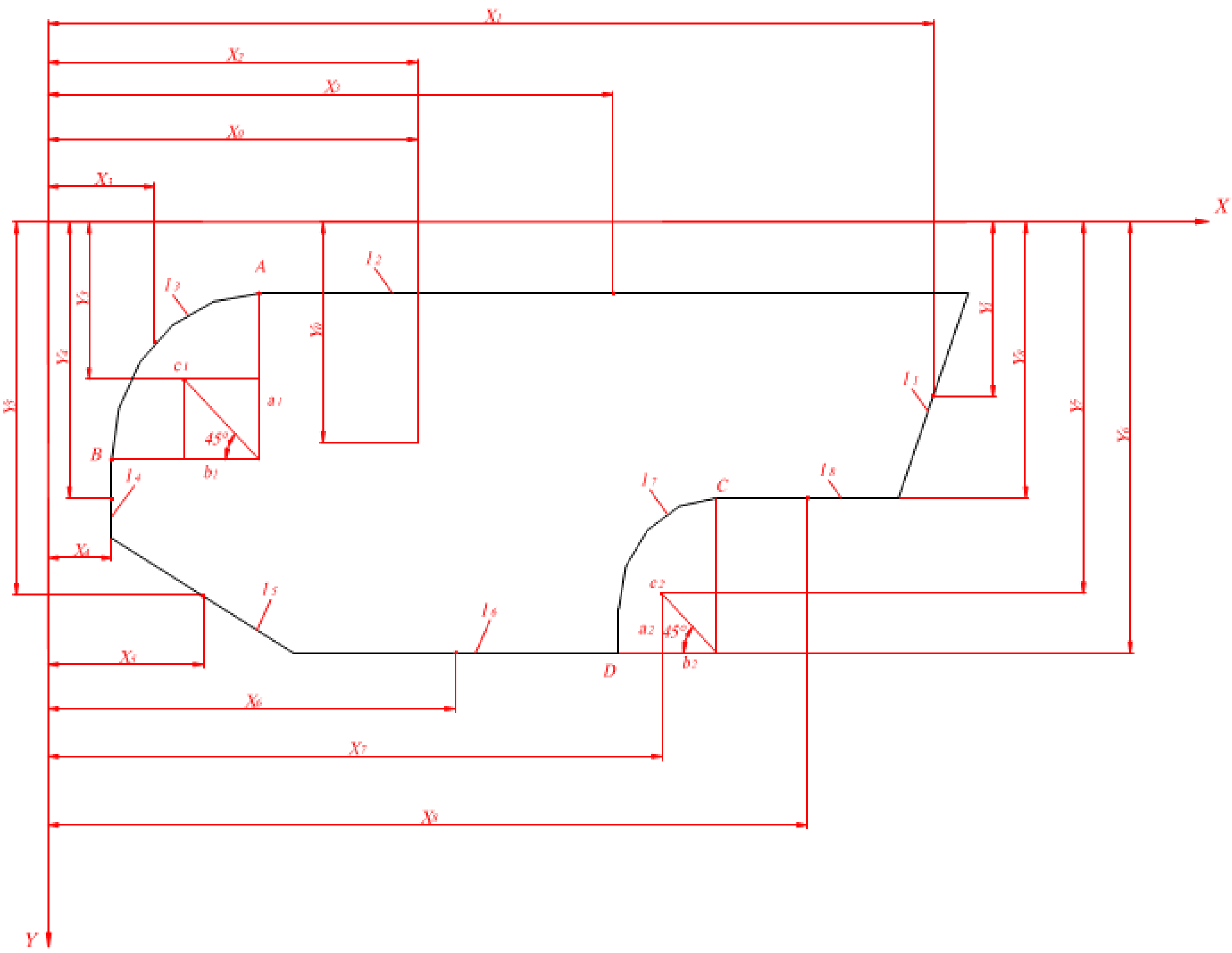


Fig 2. circuit for determining the center of pressure of a difficult cutting contour

4.2. Determination of the closed height of the stamp.

The stamp is projected in its lower working position. In this position, in the best way bound the interaction of working (punch and matrix), clamping guides and guideway or removing knots of detail and stamp.

The height of the stamp in its lower working position is called the closed height of the stamp, which must necessarily be matched to the closed height of the press.

The closed height of the press is called the distance from the slab to the press slide block in its lower position at the maximum travel and shortest length of the connecting rod. Closed height of the press indicates the maximum height of the stamp, which can be installed, to work on this press.

Stamp that has a closed high bigger than the closed height of the press, can`t be installed on this press. And if it is installed, in the event that the slider of the press will be in the extreme upper position, then at the press start its breakage may occur.

For presses with adjustable stroke closed heights are accepted in case of work at the maximum travel of the press. When decreasing the distance of travel closed height increases proportionally to the ratio.

$$\left(\frac{h_{\max} - h}{2}\right)$$

The technical characteristics of the press includes three groups of indicators: the parameters that determine the technological capabilities of the press, the size of the places for the establishment of stamps, which determine the dimensions of the stamp and the size of the elements of its connection to the press; constructive characteristics.

In presses with constant motion of a slider and a fixed table the limits of change of the closed height of a stamp are determined only by the size of regulation of a length of a connecting rod: the closed height of a stamp

the biggest $H_{max} = H - H_{пл}$, (20)

the smallest $H_{min} = H - H_{пл} - \Delta_{ш}$. (21)

On presses with a movable table and a variable slider movemens, if the press table is lowered to the lower position, the connecting rod is adjusted to the smallest length and the stroke of the press is the smallest, a stamp with the largest closed height can be installed.

$$H_{ш}^{\max} = H - H_{пл} + \frac{h_{\max} - h_{\min}}{2}; \quad (22)$$

If the press table is raised to the top position, the connecting rod is adjusted to the greatest length and the stroke of the press is the largest, then the press can be fitted with a stamp with the smallest closed height

$$H_{ш}^{\min} = H - H_{пл} - \Delta_{ш} - \Delta_{c}, \quad (23)$$

where N – nominal closed height of the press, mm;

$H_{пл}$ – thickness of the plat under the stamp, mm;

$\Delta_{ш}$ – the value of adjusting the length of the connecting rod (for dual-action presses – connecting rods), mm;

Δ_c – value of the table adjustment, mm;

h_{min}, h_{max} – respectively, the smallest and largest movement (internal and external) of the slider, mm.

Within the limits between $H_ш^{\max}$ and $H_ш^{\min}$ are all intermediate values of the closed height of the stamps installed on this press.

At some given slider movement h_0 a stamp can be installed on the press with closed height the value of which is within the range from

$$H_0^{\min} = H - H_{пл} - \Delta_ш - \Delta_c + \frac{h_{\max} - h_0}{2} \qquad (24)$$

to

$$H_0^{\max} = H - H_{пл} + \frac{h_{\max} - h_0}{2}\,. \qquad (25)$$

If $h_0 = h_{max}$ then

$$H_ш^{\min} = H_0^{\min} = H - H_{пл} - \Delta_ш - \Delta_c\,, \qquad (26)$$

$$H_0^{\max} = H - H_{пл} \qquad (27)$$

The last value of the closed height of the stamp corresponds to the nominal closed height of the press.

Example: The press of the 25 Tf model of the KD 1424 has the following technological parameters: H = 450mm, $\Delta_ш$ =55mm; Δ_c = 270mm; $h_{мax}$ =65mm; $h_{мin}$ = 5mm; $H_{пл}$ = 50mm. t is necessary to determine the possible closed height of the die mounted on this press while movement of the press slider h_o = 25 mm.

The highest closed stamp height is:

$$H_0^{\max} = H - H_{пл} + \frac{h_{\max} - h_0}{2} = 450 - 50 + \frac{65 - 25}{2} = 420mm\,;$$

$$H_0^{\min} = H - H_{пл} - \Delta_ш - \Delta_c + \frac{h_{\max} - h_0}{2} = 450 - 50 - 55 - 270 + \frac{65 - 25}{2} = 95mm$$

4.3. Selection of gaps and determination of executive (working) dimensions of the punch and matrix.

In determining the operating (working) sizes of punches and matrices for disconnection operations of sheet stamping it is necessary to proceed from the dimensions of the stamped part, its accuracy and the parameter of stamp durability. To obtain a stamped part with a given degree of accuracy, it is necessary to provide the correct choice (appointment) of gaps and tolerances on the working dimensions of the punch and matrix. In this case, the tolerances on the working dimensions of punches and matrices should be set in such limits that they provide the best gaps.

Setting the gap direction. The size of the cut out part, in the outer contour, depends on the size of the matrix. The size of the opening that breaks - from the size of the punch. Based on this we can set the gap direction, depending on which parts of the component need to hold - external or internal (covering or covered). In the case of cutting out the external contour, the nominal dimensions of the part $D_н$ are provided by the matrix, and the gap *z* is provided by reducing the size of the punch $D_п$, it means $D_п = D_н - z$. The nominal size of the matrix is assumed to be equal to the smallest dimensional dimension of the part. When punching the holes, its dimensions $d_н$ are provided to the punch $d_п$, and the gap *z* is provided by increasing the size of the matrix $d_м$, it means $d_м = d_н + z$.

Appointment (selection) of the gaps size. The value of the minimum and maximum initial bilateral gaps for various materials when working on presses with a number of moves 120 – 140 per minute are given in Table. 6 or in the table. 7. The smallest initial gaps are nominal. The largest initial gaps take into account their increases through the tolerances for the manufacture of a punch and matrix.

Table 7 - Minimal and maximal initial bilateral gaps between the matrix and the punch in stamps for cutting and punching

Material thickness *S*, мм	Material					
	Soft steel (mark 08, 10, 15, Ст.1, Ст. 2), copper, soft brass, aluminum		Steel of medium hardness (mark 20, 25, 30, 35, Ст.3, Ст.4), hard brass		Hard steel (mark 40, 45, 50, Ст. 5, Ст. 6 і вище), hard bronze	
	z_{min}	z_{max}	z_{min}	z_{max}	z_{min}	z_{max}
0,5	0,020	0,040	0,025	0,050	0,030	0,055
0,6	0,025	0,050	0,030	0,060	0,040	0,070
0,8	0,030	0,065	0,040	0,080	0,050	0,090
1,0	0,040	0,080	0,050	0,100	0,060	0,110
1,2	0,060	0,120	0,070	0,130	0,080	0,160
1,5	0,075	0,140	0,090	0,165	0,100	0,195
1,8	0,090	0,160	0,110	0,200	0,130	0,230
2,0	0,100	0,180	0,120	0,220	0,140	0,260
2,5	0,125	0,225	0,150	0,275	0,175	0,325
3,0	0,150	0,270	0,180	0,330	0,210	0,390
3,5	0,210	0,350	0,245	0,420	0,280	0,490
4,0	0,240	0,400	0,280	0,480	0,320	0,560
4,5	0,270	0,450	0,315	0,540	0,360	0,630
5,0	0,300	0,500	0,350	0,600	0,400	0,700
6,0	0,400	0,660	0,500	0,800	0,500	0,900
7,0	0,500	0,770	0,600	0,900	0,600	1,100
8,0	0,600	0,880	0,700	1,100	0,700	1,200
9,0	0,700	1,000	0,800	1,300	0,900	1,400
10	0,800	1,200	0,900	1,400	1,000	1,600
12	1,000	1,500	1,100	1,700	1,200	2,000

Tolerances on the executive (working) dimensions of the punch and matrix.

a) when cutting and punching a round profile.

In fig. 12 shows the schemes of stamping and placement of tolerance fields on the executive (working) dimensions of the punch and matrix when cutting a round hole.

Taking into account that the run-out of the matrix leads to an increase in its size and the run-out of the punch - to reduce, then their nominal sizes are given respectively: the minimum - for the matrix and the maximum - for the punch.

The dimensions of the punch and the matrix are determined by the following dependencies (see diagram):
when cutting out the outer contour:

$$D_М = (D_Н - \Delta')^{+\delta_М} \qquad (28)$$

$$D_П = (D_Н - \Delta' - z_{\min})_{-\delta_П} \qquad (29)$$

when punching the hole:

$$d_М = (d_Н - \Delta' + z_{\min})^{+\delta_М} \qquad (30)$$

$$d_П = (d_Н - \Delta')_{-\delta_П} \qquad (31)$$

where $D_п$, $D_м$, $d_п$, $d_м$ – respectively the diameters of punches and matrices when cutting and punching;

$D_н$, $d_н$ – nominal diameters of the parts;

$z_{мін}$ – minimum (guaranteed) gap between the matrix and the punch;

Δ – the tolerance field of the stamped part (on the outer contour or hole), which is given by the drawing;

Δ' – allowance for wear of the tool;

$\delta_п$ and $\delta_м$ – accordingly tolerance for the manufacture of the punch and the matrix:

In determining the operating (working) dimensions of the stamp should also take into account the allowance for the wear of the punch and the matrix Δ', which is determined depending on the required accuracy of the stamping of the part: if the tolerance on the size of the part Δ ≤ 100 microns, then the allowance for wear is taken Δ'= Δ, in the case of Δ> 100 microns, then Δ'= 0,8 Δ (the scheme of placement of tolerance fields in Fig. 12 is given at Δ'= Δ).

Total tolerances of tolerances for the manufacture of the matrix and punch should not exceed the clearance on the gap

$$\delta_п + \delta_м \leq (z_{мax} - z_{мin}).$$

The tolerances for the operating (working) dimensions of the matrix and the punch $\delta_п$ and $\delta_м$ are taken on the 7th grade of accuracy when cutting (punching) of parts with the thickness S ≤ 4mm, at S> 4mm, it is possible to take on the 8th grade.

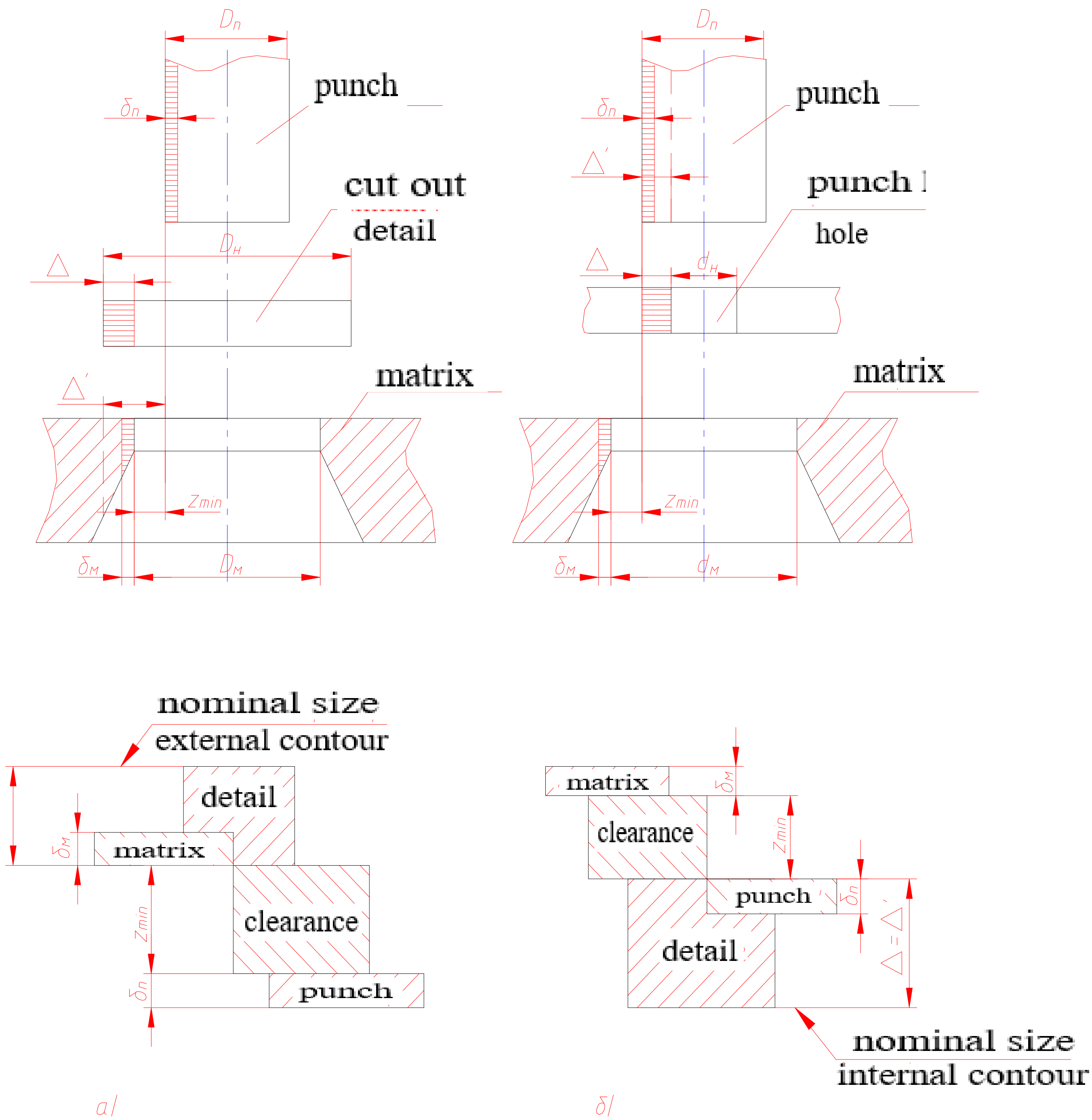


Figure 3 - scheme of stamping and placement of tolerance fields on the executive (working) dimensions of the punch and matrix during the cutting and making a round contour

a) when cutting out the external contour

b) when breaking the hole

Example: It is necessary to calculate the executive (working) dimensions of the punch and the matrix and assign tolerances to these dimensions for the washer shown in Fig. 13. Material - steel 35.

Tolerances on the dimensions of the parts are:

$\Delta 60$ = 300 microns = 0.3 mm; $\Delta 30$ = 210 microns = 0.21 mm.

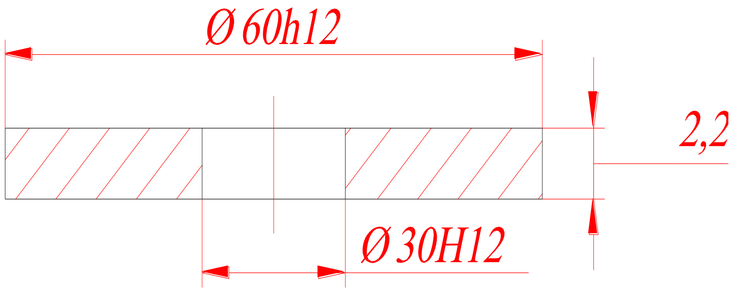


Figure 13 - Drawing of the detail for determination and calculation of executive (working) dimensions of the punch and matrix

Since the tolerances for the sizes $\Delta >$ 100 microns, the tolerances for wear on the corresponding working matrixes and the punch on these sizes are equal

$$\Delta'_{60} = 0{,}8 \times \Delta_{60} = 0{,}24 mm;$$

$$\Delta'_{30} = 0{,}8 \times \Delta_{60} = 0{,}17 mm.$$

According to Table 7 for the thickness of the material S = 2.2 mm (we take the nearest smaller value - 2.0 mm) we need to take z_{min} = 0,12 mm.

In addition, according to tolerance tables for sizes Ø 60 mm and Ø 30 mm for the 7th qualification, we find the corresponding values $\delta_{н}$ and $\delta_{м}$:

$$\delta_{м\,60} = 0{,}030 \text{ mm}; \qquad \delta_{н\,60} = 0{,}030 \text{mm};$$

$$\delta_{м\,30} = 0{,}021 \text{ mm}; \qquad \delta_{н30} = 0{,}021 \text{mm}.$$

We find the values of the dimensions of the matrix and the punch for the external contour, taking into account the allowance for wear according to the formulas 28, 29:

$$D_M = (D_H - \Delta')^{+\delta_M} = (60 - 0{,}24)^{+0.,03} = 59{,}76^{+0{,}03} mm\,;$$

$$D_П = (D_H - \Delta' - z_{\min})_{-\delta_П} = (60 - 0{,}24 - 0{,}12)_{-0{,}03} = 59{,}64_{-0{,}03} mm\,.$$

For an aperture according to formulas 30, 31 we find

$$d_M = (d_H - \Delta' + z_{\min})^{+\delta_M} = (30 + 0{,}17 + 0{,}12) -_{0{,}021} = 30{,}17_{-0{,}021} mm$$

$$d_П = (d_H - \Delta')_{-\delta_П} = (30 + 0{,}17)^{+0{,}021} = 30{,}29^{+0{,}21} mm.$$

4.4. Definition of stamp stability

On the stamping resistance have significantly influence stamping material, the thickness of the stamped material, the configuration and the dimensions of the part, the design features of the stamp, the material and the heat treatment of the parts of the stamp, the operating conditions.

During the elaboration of this sub-clause it is necessary to carry out a checking calculation of the punch, matrix or other critical elements of the equipment for durability in the case of significant stamping efforts, openings of small diameters and with considerable thickness (hardness) of the material. The material of the tool can be steel with HRC 56÷60, σ_{cm} = 1000÷1600 MPa.

To penetrate the condition of durability of the punch has the form:

$$\sigma_{cm} = P_{p1} / F \le [\sigma]_{cm} \text{ (мПа)}, \quad (32)$$

where F – is the area of the smallest cross-section of the punch, m^2;

σ_{cm} – compression stress in the punch, MPa;

$[\sigma]_{cm}$ – allowable compressive stresses for hardened steel, mPa.

Pressure on gaskets of a stamp from a punch (matrix):

$$p = \frac{P_{max}}{F_в} = \frac{kus\tau_o}{F_в} \le [\sigma]_{зм} \text{ (mPa)}, \quad (33)$$

where $F_в$ – sectional area of the upper part of the punch (matrix), m^2;

$[\sigma]_{зм}$ – permissible tensile strength of the stamp plates material, mPa.

Check for matrix strength:

a) a circular matrix with a diameter d = 2r, which rests on a plate with an internal diameter d_0 = 2ro. Bending tension

$$\sigma_{зг} = \frac{2{,}5P_{max}}{H_m^{\ 2}}\left(1 - \frac{2r}{3r_o}\right) \le [\sigma]_{зг} \text{ (mPa)}, \quad (34)$$

matrix thickness

$$H_m = \sqrt{\frac{2{,}5P_{max}}{[\sigma]_{зм}}\left(1 - \frac{2r}{3r_o}\right)} \text{ (mm)}; \quad (35)$$

b) a rectangular matrix based on a plate with a square aperture with side *a*

$$\sigma_{зг} = \frac{2{,}5P_{max}}{H_m^{\ 2}} \le [\sigma]_{зг} \text{ (mPa)}, \quad (36)$$

$$H_m = \sqrt{\frac{2{,}5P_{max}}{[\sigma]_{зм}}} \text{ (mm)}; \quad (37)$$

c) a rectangular matrix based on a plate with a rectangular aperture with sides $a \times b$

$$\sigma_{зг} = \frac{3P_{max}}{H_m^{\ 2}}\left(\frac{b/a}{1 + b^2/a^2}\right) \le [\sigma]_{зг} \text{ (mPa)}, \quad (38)$$

$$H_m = \sqrt{\frac{3P_{\max}}{[\sigma]_{зм}}\left(\frac{b/a}{1+b^2/a^2}\right)} \text{ (mm)}, \quad (39)$$

where $[\sigma]_{зм}$ – permissible bending stress, mPa.

4.5. Calculation of structural elements of the stamp

For pressing the material of the workpiece to be stamped, for removal of a product from the punch, for pushing the product from the matrix using different clamps, strippers, called buffers. The buffers can be rubber, polyurethane, metal elastic elements, as well as pneumatic and hydraulic devices. Last ones are expensive, and therefore in the press of a simple action it is recommended to use the first types of buffer devices.

An important condition for calculation of the buffer spring is that the removal force of the product should be less than effort that breaks the buffer $Q_{зн} < P_б$.

Screw cylindrical springs for buffers can be made from a wire of round, square, rectangular cross-section. The material for the springs is spring steel grades 65Г, 60C2, 60C2A. Springs harden in oil with a release, after which the hardness is HRC 38 – 45.

The developing buffer force:

- for springs with a round cross-section

$$P_б = \frac{\pi d^3 [\tau]_{кр}}{8D_{ср}} \text{ (H)}, \quad (40)$$

where d – diameter of the cross-section of the spring, mm;

$D_{ср}$ – average diameter of the spring, mm;

$[\tau]_{кр}$ – allowable torsion stress (500 MPa for steel 65Г; 550-650 MPa for steels 60C2, 60C2A).

- for springs with rectangular section of turns

$$P_б = 0{,}416\frac{c^3[\tau]_{кр}}{D_{ср}} \text{ (H)}, \quad (41)$$

where c – width of a turn, mm.

- for a combined spring

$$\sum P = P_1\left(1+\frac{d_2^2}{d_1^2}+\frac{d_3^2}{d_1^2}+...+\frac{d_n^2}{d_1^2}\right) \text{ (H)}. \quad (42)$$

Plate spring allow to create significant efforts at small dimensions. The total compression force is equal to the sum of the forces of individual springs. Material of the springs is steel 60C2A, heat treatment – tempering with the release to HPC 46-50. Effort which create plate spring

$$P_б = \frac{200\cdot s^2(1+tg\alpha)^2}{\sqrt[8]{n}(2{,}4-2d/D)} \text{ (H)}, \quad (43)$$

where s – the thickness of the spring washer;

α – angle of inclination of the surface of the spring washer, $\alpha = 4 \div 7°$;
n – number of springs;
d – inner diameter of the spring;
D – outer diameter of the spring.

Rubber and polyurethane are used for strippers, pushers and pressers in die stamping machines. The shape and dimensions of rubber and polyurethane buffers are chosen depending on the required effort. Material of springs: sheet technical oil-and-gas-resistant rubber, hardness of rubber 50-70 by Shore; Polyurethane brand SKU-7L, hardness of polyurethane 76-86 by Shore.

Effort which create rubber (polyurethane) buffer

$$P_{б} = pS_{оп} \text{ (H)}, \qquad (44)$$

where p – pressure when compressing the buffer, MPa;

$S_{оп}$ – bearing buffer area, cm^2.

For a rubber buffer, maximum compression is recommended to take no more than 45% (preferably 25÷30%).

After selecting a buffer device, be sure to check the condition $Q_{зн} < P_{б}$ and give the scheme of placement of the device with indication of its constructive parameters.

4.6. Description of the structure and the principle of the stamp

According to the previous analysis and calculations it is necessary to develop a technological scheme of stamping the product with the following graphic image and describe the implementation of the technological process.

5. Choice of equipment and its technical characteristics

According to preliminary calculations for maximum stamping effort P_{max}, dimensional details and other structural and power parameters in finally accepted model of press equipment. Choose the main design and technological characteristics of the equipment, the results need to draw in the form of a table.

Conclusion

In conclusion, to the course work should indicate the results of developments, recommendations for improving the technological process of manufacturing this product by sheet stamping.

APPENDICES

Appendix 1

The value of the resistance to cutting (punching) τ_0 for the most common metals [4]

Material	Soft metal (annealed)	Solid metal (clutched)
	τ_0, МПа	τ_0, МПа
Steel 08	250 – 280	320 – 350
Steel 10кп; 15кп; Ст1	280 – 300	350 – 380
Steel 20; Ст2	300 – 320	380 – 420
Steel 25; Ст3	320 – 350	420 – 450
Steel 30; Ст4	350 – 380	450 – 500
Steel 35; Ст5	400 – 450	500 – 550
Steel 40—45; Ст6	450 – 500	550 – 580
Stainless steel	520	560
Stainless steels 12Х18Н9; 12Х13	360 – 380	–
ball-bearing steel ШХ15	460 – 520	–
Copper M1; M2; M3	180 – 220	250 – 280
Brass Л63; Л68	220 – 280	350 – 400
Aluminum АД; АД1	70 – 90	110 – 150
Duralumin Д1; Д16	140 – 180	260 – 380

Annex 2

Basic characteristics of crankshaft specifications [9]

Technological characteristics	
Stamp effort, thousands	P
Inner and outer sliders stroke: - minimum, mm - maximum, mm	h_{min} $h_{max}h$
Frequency of slider movement, rpm	n
The nominal closed height, mm	H
Nominal closed height of external slider of double action press, mm	$H_{нар}$
Thickness of under stamp plate, mm	$H_{пл}$
Connecting rod length adjust, mm	$\Delta_{ш}$
Adjusting the table, mm	Δ_{c}
Overhang, mm	R, R'
The distance between the guides, mm	$L_{н}$
The distance between racks, mm	L_{c}
The greatest stroke of toper ejector, mm	$h_{в.в}$
The greatest stroke of bottom ejector, mm	$h_{н.в}$
efforts to lower ejector, thousands	$P_{н.в}$
clamp efforts, thousands	Q

The sizes of windows in racks: - width, мм - height, мм - windows height of above the table, mm	A_o H_o l_o
Technological work, kgp·m	A
The largest weight of stamp that is hung to slider, kg	$m_{ш}$
Sizes of stamp installation places	
Table dimensions: - length, mm - width, mm	A_c B_c
The dimensions of the hole in the table: - diameter, mm - length, mm - width, mm	D_c a_c b_c
The dimensions of the hole in the under stamp plate, mm	$D_{пл}$ $d_{пл}$ $h_{пл}$
The dimensions of slider (double action presses – internal slider): . - length, mm - width, mm	 $A_{пз}$ $B_{пз}$
The dimensions of the central hole in slider (double action presses – in the inner slider) for fixing the top of the stamp, mm	$d_{пз}$ $l_{пз}$
Design characteristics	
Overall dimensions of machine: - length, mm - width, mm - height above the floor, mm - level of the table, mm	$A_Г$ $B_Г$ $H_Г$ H_c
Main drive motor power, kW	$N_{гл}$

Technological parameters of the simple-action stamps

One-rack one-crank with movable table											
Model	P	h_{min}	h_{max}	n	H	$H_{пл}$	H_p	$\Delta_ш$	Δ_c	R	R'
КД1424	25	5	65	120	450	50	210	55	270	190	180
КД1426	40	10	80	100	500	65	250	65	300	220	210
КД1428	63	10	100	90	530	80	280	80	290	260	250
К1430	100	25	130	40	560	100	320	100	280	320	310
КА1432А	160	20	120	70	600	120	360	120	260	360	350

One-rack with unmovable table

Model	P	h_{min}	h_{max}	n	H	$H_{пл}$	$\Delta_ш$	R	L_c
К2114	2,5	4	30	200	150	25	25	95	120
КД2114	2,5	4	36	200	180	36	32	100	130
К2116Б	4,0	45	-	320	160	32	32	100	130
КД2118	6,3	5	50	150	200	45	40	150	140
К2118Б	6,3	5	45	150	170	32	32	110	120

КД2120	10	5	50	120	200	32	40	130	170
КД2122	16	5	55	120	220	40	45	160	200
КД2I24	25	5	65	120	450	50	55	190	240
КД2126	40	10	80	100	280	65	65	220	280
КД2128	63	10	100	90	340	80	80	260	340
К2130	100	25	130	80	400	100	100	320	400
КЕ2130	100	10	130	100	400	100	100	340	400
К2132	160	25	160	70	480	120	120	360	480
К2132А	160	25	160	50	480	120	120	360	480
К2232	160	160	-	37	480	120	120	360	480
К2234	250	200	-	35	500	140	140	400	500
К0134	250	200	-	32	560	140	140	400	-

Dimensions of places for stamp installing in single action crank press

Model	A_c	B_c	D_c	a_c	b_c	$D_{пл}$	$d_{пл}$	$h_{пл}$	$A_{пз}$	$B_{пз}$	$d_{пз}$	$l_{пз}$
КД1424	500	340	210	250	170	130	100	20	280	225	40	60
КД1426	600	400	250	300	200	130	100	20	350	285	50	70
КД1428	710	480	300	360	240	170	140	30	370	310	50	75
К1430	850	560	360	420	280	240	200	30	330	295	60	85
КА1432А	1000	670	420	480	320	240	200	40	460	560	75	85
К2114	260	170	90	–	–	70	50	15	110	80	25	50
КД2114	280	180	90	–	–	70	50	15	120	95	25	55
К2116Б	280	180	120	140	90	70	50	15	95	95	25	45
КД2118	360	280	120	150	100	80	60	15	170	145	32	58
К2118Б	300	200	120	150	100	80	60	15	170	135	32	50
КД2120	360	240	150	180	115	80	60	15	195	162	30	60
КД2122	420	280	180	210	140	110	80	20	220	190	40	60
КД2124	500	340	210	250	170	130	100	20	280	225	40	60
КД2126	600	400	250	300	200	130	100	20	350	285	50	70
КД2I28	710	480	300	360	240	170	140	30	370	310	50	75
К2130	850	560	360	420	280	240	200	30	330	295	60	75
КЕ2130	950	630	360	420	280	240	200	40	450	410	60	70
К2132	1000	670	420	480	320	240	200	40	460	580	75	85
К2232	1000	670	420	480	320	240	200	40	665	560	75	100
К2234	1120	750	480	530	360	–	200	–	860	670	75	75
К0134	1120	750	480	530	360	240	200	40	930	730	75	120

Design characteristics of single action crank press

Model	$A_Г$	$B_Г$	$H_Г$	H_c	$N_{Гл}$
КД1424	1170	1200	2145	650	2, 7
КД1426	1270	1375	2565	755	4,7
КД1428	1500	1800	3020	790	9,0
К1430	1555	1850	2935	750	14,5
КА1432А	2340	2100	3465	820	19,0
К2114	515	800	1535	810	0,4
КД2114	600	825	1585	800	0,37
К2116Б	585	850	1715	830	0,5
КД2118	620	970	1805	800	0,75
К2118Б	590	915	1795	850	0,8
КД2120	965	1045	1790	745	2,0
КД2122	990	1085	1875	760	2,0
КД2124	1170	1190	2110	820	2,7
КД2I26	1270	1350	2420	835	4,7
КД2I28	1450	1730	2180	840	8,3
К2130	1555	1850	2725	700	14,5
К2I30Б	1440	1910	2650	700	10,0
К2132	2100	2340	3650	820	19,0
К2232	1790	2065	3560	820	10,0
К2234	2300	2450	3950	800	20,0
К0I34	2640	2700	4810	720	27,0

Technological characteristics of simple action closed presses

One crank

characteristic	Model						
	КА2534	К2535А	КА2536	К2538	К2540	К2542	К2544
1	2	3	4	5	6	7	8
P	250	315	400	630	1000	1600	2500
h	200	400	250	320	400	400	600
n	32	16	25	20	16	10	6

H	560	710	670	800	950	1120	1380
$H_{пл}$	140	140	160	180	220	320	300
$\Delta_ш$	140	140	160	180	200	220	220
$H_н$	560	560	460	750	960	1120	1400
$L_н$	720	840	850	1080	1300	1620	1770
L_c	860	!000	1000	1250	1480	1830	2000
$h_{нв}$	100	200	200	130	200	250	300
Q	50	80	63	105	200	350	50
$P_{нв}$	6,6	8	7	7,8	14	20	50
A_o	520	600	700	990	1150	1560	1400
H_o	560	530	500	620	750	980	1100
l_o'	-	150	130	140	200	150	300
A	1570	5600	2940	5500	12000	20000	31600
$m_ш$	1000	1000	1000	1150	2460	5000	5000

Double crank

Model	P	h	n	H	$H_{пл}$	$\Delta_ш$	Q	L_c	$h_{в.в}$
К3730А	100	160	50	500	100	160	10	1450	40
КБ3732	160	200	48	630	140	200	20	2010	86
К3732	160	200	ЗО	600	130	160	32	2000	86
К3534	250	200	25	630	160	250	28	2510	140
КА3534	250	400	25	750	160	250	32	2510	140
К3535А	315	400	25	750	180	250	32	2500	140
К3735	315	250	24	750	190	200	32	2500	140
К3735А	315	500	18	1000	190	400	32	2500	140
К3536	400	250	20	750	190	200	80	2500	180
К3537	500	250	20	750	220	200	80	2500	180
КБ3537	500	250	25	750	190	200	80	2500	180
К3539	800	315	17	900	250	250	160	2500	180
КА3539	800	315	17	900	250	250	80	2500	180
К3540	1000	400	20	1060	250	320	26,6	3150	150
К3542	1000	400	16	1060	300	360	320	5000	150
К3544	2500	500	11	1250	300	500	500	4000	150
К3546	4000	630	10	1500	320	200	800	5000	250
К3046	4000	500	10	1180	320	300	800	12000	200

Dimensions of places for stamp installing and design characteristics of closed simple action crank presses

Model	A_c	B_c	$A_{пз}$	$B_{пз}$	$A_Г$	$B_Г$	$H_Г$	$N_{гл}$
КА2534	850	850	670	650	3000	2970	5140	27
К2535А	1000	1000	800	800	3100	3140	5770	39,9
КА2536	1000	1000	800	800	3410	3140	5930	39,9
К2538	1250	1250	1000	1000	3280	3470	6190	58
К2540	1250	1250	1250	1000	4540	3800	6990	77
К2542	1800	1800	1440	1500	5050	4620	8720	125
К2544	2000	2800	1600	2100	5390	4870	9125	132
К3730А	1250	800	1400	700	3085	1740	4010	17
КБ3732	2000	1250	1950	1000	3550	2250	4570	20
К3732	2000	1250	1950	1000	3125	2400	4490	13
К3735А	2470	1250	2440	1000	4290	2210	5890	40
КА3534	2500	1250	2470	1000	4070	2700	5840	29
К3534	2500	1250	2470	1000	4480	2900	5085	30
К3535А	2500	1250	2470	1000	4555	2900	5855	50
К3536	2500	1400	2400	1000	4350	2470	5660	40
К3735	2500	1250	2440	1000	4290	2210	5385	40
К3537	2500	1400	2440	1200	4350	2470	5Ь60	40
КБ3537	2500	1400	2400	1200	4265	2870	6220	45
К3539	2500	1500	2280	1300	4485	2800	6245	55
КА3539	2500	1500	2470	1320	4375	2975	6520	58
К3540	3150	1800	3066	1700	6000	4740	7970	160
К3542	5000	2000	4750	1800	6500	4800	8450	160
К3544	4000	2000	3750	1800	7980	5000	9015	160
К3546	5000	2000	5000	2000	7640	5980	1490	250
К3046	11500	2000	11000	1900	12570	6750	9850	250
К4540	4620	2464	4570	2440	7970	5440	9970	160
К4542	3150	2500	3100	2500	6240	5420	7000	155
К4546	5000	3000	4950	3000	8520	7000	9125	245

ДЛЯ НОТАТКІВ

Навчально-методична література

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МЕТОДИЧНІ ВКАЗІВКИ

до виконання курсової роботи з дисципліни «ТЕХНОЛОГІЯ ОБРОБКИ ДЕТАЛЕЙ ТИСКОМ»

для здобувачів вищої освіти з числа іноземних громадян за спеціальністю 131 – «Прикладна механіка»

Комп’ютерне макетування та верстка *А.П. Катрич*

Формат 60х90/16. Обл. вид. арк. 1,43. Тираж 10 прим. Зам. № 3097.

Тернопільський національний технічний університет імені Івана Пулюя.
46001, м. Тернопіль, вул. Руська, 56.
Свідоцтво суб’єкта видавничої справи ДК № 4226 від 08.12.11.