Ministry of Education and Science of Ukraine
Ternopil National Technical University named after. I. Puluj
Department of Mechanical Engineering Technology

НАВЧАЛЬНО-МЕТОДИЧНА ЛІТЕРАТУРА

ТНТУ

Methodical manual on the implementation of the course project on discipline "Designing of machine-building industries"

for students of all forms of study
Direction of preparation 131 " Applied mechanics"

Ternopil

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Ministry of Education and Science of Ukraine
Ternopil National Technical University
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Mechanical Engineering
department

Methodical instructions

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Ternopil – 2021

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Coursework structure

The course work consists of a graphical part and an explanatory note. The starting data for the work are the name of the product and its assembly unit, their marking or model, the annual program of production, the complexity of machining, the basic operations of mechanical processing of the component unit and the artificial time for their execution, as well as the mass of the main product.

The volume of the explanatory note - 25… 35 sheets of A4 size.

The graphic part of the course work is performed on A1 sheets, which should show:

- layout plan of the assembly shop;
- plan of placement of equipment at the site of production of the assembly unit;
- cross section of the span of production and auxiliary buildings;
- specification of the equipment of the production unit of the assembly unit.

Clarification of the program and the complexity of production

The production program of the workshop is determined based on the production program of the plant, taking into account the established percentage of spare parts. It should be borne in mind that often parts and assembly units are manufactured by adjacent factories. Accordingly, in order to develop a detailed or detailed production program, you must have the following data:

- drawing number of the node and details;
- the name of the node or part;
- brand of material;
- type of workpiece;
- the number of parts for the product and spare parts;
- number of parts per production program;
- the mass of the workpiece and the product.

Detailed (detailed) annual production program in the shop is made out in the form of table 1.

Table 1- Detailed (detailed) annual production program in the shop

№	№ of the drawing		The name of the detail	Brand of material	Type of workpiece	Number of parts per item	%% on spare part	Number of parts			Weight, kg		Weight per program, tons	
	node	detail						to the main prog-ram	on spare parts	in total	work - piece	detail	blanks	detail

The production needs to have data on the complexity of manufacturing the product.

The complexity of machining for mass and large-scale production can be defined by

$$Tm = \sum T_{шт}$$

where $T_{шт}$ is the artificial time for the operation of the technological process, min.

For batch, small batch and single production types:

$$Tm = \sum T_{шт-к}$$

where $T_{шт-к}$ is the artificial-calculating time for the operation of the technological process, min.

The complexity of manufacturing the assembly unit

When it comes to determining the complexity of product assembly, there are two ways:

a) in terms of complexity of assembly work per 1 ton of product weight;

b) according to factories of previously completed projects based on the complexity of manufacturing the details of this product.

The entire complexity of assembly can be divided into the complexity of the fitting works and the complexity of nodal and general assembly.

In single and small-scale production, the proportion of fitting and assembly works is increasing, since the latter are carried out mainly at one workplace (stand).

The complexity of assembly work for the annual program of production is determined in percentage of the complexity of machining. Depending on the type of production, it is: in single and small-scale production 30 ... 35%, in large-scale and mass production - 20 ... 25%.

In the conditions of mass production and mass production in order to shorten the cycle of assembly and increase productivity, the product is decomposed into separate units, assembly of which is carried out in parallel with the use of current methods of labor organization.

When designing mechanical assemblies, along with the characteristics and nomenclature of products, it is necessary to have data on the complexity of manufacturing products. Calculated complexity includes all the normalized on technological processes of processing on machines and on manual operations.

Depending on the design stage, type of production and other factors, the complexity of manufacturing a product can be determined by different methods, among which three are distinguished as basic, but fundamentally different from each other: empirical, expert and technological calculation.

It should also be noted that the selection of equipment, its justification and the determination of machine-tool (labor) production of parts and their assembly into products are impossible without the widespread use of computer-aided design of technological processes for workshops and sections of mechanical assembly plants.

Specification and quantity of process equipment

The number of equipment on the station is calculated as the ratio of artificial time at each of the operations of the process to the release time

$$m_p = \frac{T_{шт}}{t_в}$$

The result is rounded to the integer value. The calculation is performed for each type of machine.

The specification of the basic process equipment of the machine shop section is formalized in the form of table 2.

Table 2 - Specification of the basic process equipment of the machine shop section for

№	The number and name of the operation	Name and model of equipment	Quantity, items.	Dimensions, mm
1				
2				
….				
In total				

It should also be borne in mind that in addition to the main on the station is ancillary equipment (installations for washing parts; control tables; workbenches; devices for transporting, accumulating and feeding workpieces and parts).

Calculation of the number and composition of employees

For the implementation of production processes in mechanically assembled production there is a certain staff of employees, which is divided into the following categories: production (basic) and auxiliary workers, engineering and technical workers, employees, junior service personnel.

Manufacturing workers are workers of mechanically assembled production who directly carry out operations of technological process on production of products.

Ancillary workers are not directly involved in the production of the production program, but are engaged in the maintenance of technological processes.

Engineering is called an employee who performs the duties of management, organization and preparation of production and occupies positions that require the qualification of an engineer or technician.

Employees in accordance with the position they occupy, perform administrative and economic functions, maintain financing, accounting and statistical accounting, solve social and other similar issues.

The junior staff consist of couriers, guards, wardrobes and cleaners of household and office premises.

The calculation of the number of production workers-machine-tool makers can be done by the number of machine tools adopted in the project:

$$P_B = \frac{C_n \cdot F_\partial \cdot k_з}{F_{\partial р} \cdot k_б}$$

where $C_П$ is the number of machines adopted in the project;

F_∂ - valid annual equipment operation fund, hours (taken from table 1);

k_3 - coefficient of loading of the equipment, at two-shift operation for single and small-scale production - 0,85; for serial - 0.8; for large-scale and mass production - 0,7;

$F_{\partial р}$ is a valid annual working time fund of workers, accepted for production with a 41-hour working week - 2070; for productions with a 36-hour working week - 1830 hours;

$k_б$ - coefficient of multilevel service, accepted for single and small-scale productions - 1,1 ... 1,2; in serial 1,3 ... 1,5, in large serial - 1,5 ... 1,8; in mass 1.8 ... 2.2).

The number of auxiliary workers is determined as a percentage of the number of machine-workers. The number of engineers, employees and junior support staff is determined as a percentage of the total number of employees of the site. The obtained data is recorded in the composition of the workers of the mechanical section or workshop (Table 4).

Table 3 - Actual annual fund of work of equipment of mechanical shops

Equipment	Operating mode (number of shifts)		
	one	two	three
Metal-cutting machines weighing up to 10 tons from 10 to 100 tons	2040 2000	4060 3985	6060 5945
Metal-cutting machines with a CNC weighing up to 10 tons from 10 to 100 tons	– –	3890 3810	5775 5650
Агрегатні верстати	–	4015	5990
Flexible production modules weighing up to 10 tons from 10 to 100 tons	– –	– –	5970 5710

Table 4 - Statement of the composition of the working mechanical section

Categories of employees	The method of determination	Percentage ratio	Number
Production workers a) workbenches b) locksmiths	by the formula in% of the number of machine tools	3 ... 55% in single and small-scale production; 1 ... 3% in large-scale and mass	
Total production manufacturers			
Support workers	in% of the number of production workers	18 ... 25% in single and small-scale production; 35 ... 50% in large-scale and mass	
Total number of workers			
Controllers	in% of the number of production workers	5 ... 7%; in single and small-scale production; 8 ... 10% in large-scale and mass	
Engineering staff	in% of the total number of workers	10...13 %	
Employees	in% of the total number of workers	4...5 %	
Junior staff	in% of the total number of workers	2...3 %	
Total working			

Design of auxiliary and service departments

Determination of the total area of the assembly shop is based on the data on the complexity of work on the technological processes of manufacturing parts in the conditions of production of the base enterprise. The initial data for determining the area of the workshop are the number and dimensions of equipment at the base enterprise, namely:

- machines of machining department, units;
- machine shop repair base (CRB) machines, units;
- machines for the equipment repair section, units.
- dimensions of machine tools of machining department.

Machining department. The production area of the machining department is determined by the specific area per unit of equipment according to the rules of technological design:

$$S_м = N \cdot S_n$$

where N is the number of machines of the department of machining, pc .;

S_n - specific area per machine, m^2.

For light machine tools the specific area is 14 ... 18 m^2, for medium - 18 ... 22 m^2, for large - 22 ... 30 m^2, for especially large - 30 ... 100 m^2.

Testing department. The area of the assembly department is taken within 30 ... 40 % of the area of the mechanical department.

The ancillary area consists of the sum of the areas occupied by the subsidiary offices.

Tool sharpening department. The sharpening department is intended for the centralized sharpening and ongoing repair of the cutting tool used in the shop. It is organized when the number of equipment in the machine shop is 150 ... 300 pcs., With a smaller number of equipment the restoration of the cutting tool is carried out in the tool shop.

For larger calculations, the number of general purpose grinding machines is assumed to be equal to 3 ... 5 % in flow production, and 3 ... 4 % in the

non-flow grinding equipment, which is served by the grinding department. A smaller percentage of sharpening machines are accepted when the number of machines serviced by a branch of up to 200, more - when the number of machines is more than 500.

Branch area is determined by the specific area per unit of equipment. The specific area is 8 ... 10 m^2 per grinding machine.

Guild repair bases of mechanical workshops provide for the overhaul of maintenance of production equipment, as well as for the performance of overhaul works, the content of which depends on the accepted form of organization of repair works. In small workshops with less than 100 machines, it is not advisable to set up a workshop to repair the equipment.

The department for repair of electrical equipment and electronic systems is used for periodic inspection and repair of electric motors, means of electro-automation, control systems of equipment, etc. Its area is a part of WRB and makes 35… 40 % of its area.

The area of the repair base is determined by the specific area per unit of equipment, which is 20… 30 m^2.

Equipment and tools repair department. Branch area is determined at the rate of 20 ... 22 m^2 per unit of equipment.

Control department. Control units in the production line are located at the end of the production lines, and in the non-production line they are placed along the windows for better natural illumination of workplaces or on the way of moving parts to the assembly room. Mechanical assemblies also create checkpoints, which are intended for periodic inspection of control means and technical supervision over their proper operation, identification of the reasons for the lack of parts and selective inspection of the parts they manufacture. The area of the check point is determined at the rate of 0.1… 0.2 m^2 per machine tool, but not less than 25 m^2 per item.

The area of the control compartment is determined from the calculation of 5 ... 6 m^2 per controller, taking into account the additional area for the placement of the control equipment, which is taken into account by the correction factor kp = 1,75.

Compositions of materials and blanks. To ensure the normal operation of mechanical assembly shops in their composition provide a whole complex of warehouses. These include warehouses of metal and billets, warehouses of parts, assemblies and components, warehouses of finished parts and products, intermediate warehouses, tool-dispensing barns and barns of technological equipment.

The area of composition of materials and workpieces is determined according to:

$$Sc = \frac{Q_\Sigma \cdot t}{m \cdot q \cdot k_R}$$

where Q_Σ is the mass of material and billets of annual volume of output, t;

t is the number of working days of storage of blanks in the warehouse (table 5);

m - number of working days per year;

q - permissible load per 1 m^2 of floor area of the warehouse, when storing materials and workpieces in stacks q = 1,2 ... 1,4 t / m^2, in racks - 2 ... 7 t / m^2 depending on the stacking height;

k_R is the utilization area of the storage area, k_R = 0.3… 0.4.

The mass of material and workpieces of the annual volume of issue is equal to:

$$Q_\Sigma = 1.2 \cdot Q \cdot N$$

where Q is the mass of the products, t;

N - annual release program, pcs.

Table 5 - Storage standards of workpieces in working days

Type of production	Rod material, small and medium billets	Large blanks
Single	12	5
Small-scale	8	3,5
Serial	6	2.5
Large-scale and mass	4...6	1...2

The mass of material and workpieces of the annual output is:

$$Q_{\Sigma} = 1.2 \cdot Q \cdot N$$

where Q is the mass of the products, t;

N - annual release program, pcs.

If the composition of materials is combined with the procurement department, then its area is increased by 50 %.

To perform the work in the procurement department, the use of specific equipment, which includes turning-cutting, circular saws, hacksaws and circular saws, milling-centering machines, presses and other equipment. For mechanical assembly shops with a small number of automatic machines and revolving machine tools, 4 to 10 machines are installed in the workpiece compartment. The specific area is 25… 30 m^2 per machine.

The intermediate composition. The intermediate storage is the place of accumulation and storage of fully processed parts that are awaiting receipt for assembly. Other components are also included here: bearings, gaskets, electrical equipment, etc. The area of the intermediate composition is equal to:

$$Scn = \frac{Q_p \cdot t_1}{m \cdot q \cdot k_R}$$

Where *Qp* is the mass of the parts of the annual release program to be stored, t;

t_1 is the number of working days of the stock (table 6).

Table 6 - Number of working days of the stock

Types of production	Big details	Average details
Small-scale	8 days	20 days
Serial	5 days	12 days
Large serial	1 shift	2 shift
Mass	2…4 hours	8 hours

Department for the preparation and distribution of lubricants, oils. This department is intended for supply of machines with lubricating and cooling liquids. Its total area is 35 ... 120 m^2, depending on the number of production equipment (Table 7).

Table 7 - Regulatory data for determining the compartment area for the preparation and distribution of lubricants

Number of machines	Area, m^2
30…60	35…40
61…100	40…50
101…200	50…70
201…300	75…100
301…400	100…120

The area of the oils warehouse are taken equal to 10 ... 20 m^2.

Chips collection and processing department. When choosing the methods of removal and processing of chips determine its amount, which in large calculations is taken equal to 10 ... 15% of the mass of finished parts.

Branch area can be determined depending on the number of production equipment of the machine shop according to table 8.

Table 8 - Regulatory data to determine the area of separation of the removal and processing of chips

Number of machines	Branch area, m^2
to 60	65…75
61…100	75…85
101…200	85…105
201…300	110…125
301…400	130…180

Department of removal and processing of chips located near the exterior walls of the building near the exit of the shop or in basements with ramps for exit.

The results of the calculations are reported to the workshop area Table 9

№	Branch name	Area, m^2
1	Machining	
2	Assembly test	
3	Sharpening the tool	
4	Workshop Repair Base (WRB)	
5	Repair of equipment and tools	
6	Control	

№	Branch name	Area, m^2
7	Compositions of materials and blanks	
8	The intermediate composition	
9	Preparation and distribution of lubricants	
10	The composition of oils	
11	Chips harvesting and processing	
	Total	
12	Main thoroughfares (12 ... 15% of the area of all branches of the shop)	
	Total (workshop area)	
13	Office premises (25 ... 30% of the workshop area)	
	Total	

The area of the site for the manufacture of an individual part depends on the size and weight of the machines and equipment used in its production. According to the technological process developed and the equipment used, determine the area of the site for the manufacture of certain parts. The results are summarized in table 10.

Table 10 - Area of manufacturing station

Equipment	Model	Dimensions, mm	Type	Accepted area, m^2
The total area of the machining section				

Calculation of the number of vehicles in production

When designing a site (workshop) project, it is necessary to choose the means for: transporting the workpieces to the machine shop; loading and unloading of blanks; transfer of parts between machines; installation and removal of machine parts; transportation of finished parts to the assembly site or warehouse; cleaning and transportation of shavings, as well as containers for transportation and storage of blanks and parts.

The types and number of vehicles are determined on the basis of the calculations of the annual loads of parts and shavings on the site or workshop. For the vehicles selected, a brief technical specification describing the purpose must be provided.

The main types of hoisting and transport equipment for in-house cargo transportation are:

- road transport;
- terrestrial trolley transport;
- crane equipment;
- outboard transport (conveyors);
- conveyors (ground);
- automatic lifting vehicles.

Road transport is also used for inter-hull transportation of metal, billets, components, finished products, metal scrap. The main type of road transport are on-board vehicles and dump trucks with a carrying capacity of 2.5… 7.5 t.

Ground trolley trucks with a lifting platform and hoisting devices are widely used in workshops and warehouses. In this case, it is advisable to use electrically driven machines to work inside the structures. The most common types of land transport:

- electric trucks (distance of movement 50… 300 m; carrying capacity of 0,25… 5 tons; speed of movement 7… 15 km / h);

- electric loaders (displacement up to 120 m; load capacity 0,5… 2 t; speed of movement up to 3.5 km / h);

- ground stackers (displacement up to 300 m; load capacity 0,1… 2 t; speed of movement 3… 7 km / h, lifting height up to 4,5 m);

- hand trucks (moving distance up to 50 m; lifting capacity up to 0.5 t; moving speed up to 3 km / h).

Crane equipment. The crane equipment includes:

- one-way bridge cranes (5… 15 t) and two-way cranes (15/3, 20/5, 30/5, 50/10, 75/20 t); span of 10.5… 34.5 m; lifting height 16… 32 m; travel speed 70… 120 m / min. Recommended distances of up to 50 m;

- single-beam overhead cranes are used as technological transport, as well as for loading and unloading work inside the shop. Recommended travel distances are 30… 50 m. The type of single-girder cranes includes:

- a) single-beam overhead cranes (1… 5 t) with a span of 3… 12 m, lifting height up to 6 m and a travel speed of 30 m / min;

- b) single-beam bridge cranes (1… 5 t) with span 4,5… 28,5 m, lifting height up to 6 m and speed of movement 25… 60 m / min .;

- cantilever cranes (swivels) are used for moving loads over short distances. Loading capacity 0,25… 3 t; boom departure 3… 6 m;

- monorail used for servicing individual jobs when transporting long distances and inter-flight cargo transfer. Loading capacity 0,1… 10 t, lifting height up to 6 m, lifting speed 8 m / min., Traveling speed 20 m / min .;

- stacker cranes (supporting, suspension) combine the properties of cranes and forklifts. Advantages: high performance, easy control, high maneuverability. Capacity from 125 kg to 5 t, lifting height up to 12,4 m, speed of movement up to 60 m / min

Outboard transport. This type of transport includes: suspended conveyors (load-carrying, pushing, hauling, combined), one-lane roads, self-propelled trucks and tractors. Transportation distances up to 1000 m; carriage capacity of carriages 250, 500 and 800 kg, speed range 0.3… 31.5 m / min.

Land conveyors and conveyors. Depending on the size, weight and shape of the parts and products being worked, as well as the nature of the process and the volume of the production program, several types of ground conveyors are used.

Rollers: stationary, portable, mobile, wheel, ball, drive, non-drive, horizontal, inclined. Weight of transported products 25 - 100 kg. (maximum - 1200 kg.), the slope of the canvas is 1… 3 % (depending on the type and weight of cargo), the speed of movement is up to 9 m / min. Used mainly for the in-house transportation of finished parts, assemblies and components at distances up to 30 m;

Rampages up to 10 m long with a slope of 1:10, 1:15 Designed to move bodies of rotation;

Sliding troughs with a slope of 1: 1, 1: 5. Used to move flat or container parts;

Tape. There are stationary, portable, sliding on rollers. Capacity up to 250 kg, conveyor speed 6… 30 m / min., Transport 30… 60 m / min .;

Plate. This type is used in assembly line production lines as technological transport for assembly of small, medium, and also relatively heavy products (general assembly of cars). Length up to 200 m, width from 400 to 1600 mm. The speed of the working conveyor is 1… 5 m / min, transport 7… 20 m / min.

Trolleys (vertically closed (with tipping and trolleys), horizontally closed, with continuous (transport) and pulsating movement. The type of trolley conveyors provides load capacity from 10 to 8000 kg., Width of 160… 200 mm., Speed of 0.2… 6 m / min, pulsating 6… 8 m / min, transport up to 12 m / min .;

Stepping (the pulsating movement of loads occurs by alternating reverse horizontal and vertical movements of the moving frame on which the loads are placed). Used for assembly of machines, engines. Length 25… 60 m, speed 5… 10 m / min., Weight of transported cargo 1… 7 t, time of one cycle of movement 2… 6 min.

The number of vehicles and hoists required for the timely provision of workshops with materials, workpieces, parts and units can be determined by calculations based on the mass of goods being moved or other data.

The number of elements of wheel transport (electric carts, stackers, forklifts, etc.) is determined by the formula:

$$E = \frac{Q \cdot k_n \cdot T_{np}}{Q_в \cdot k_в \cdot F_д \cdot 60}$$

where Q is the annual turnover, t ($Q = Q_\Sigma$);

$k_н$ - coefficient of non-uniformity of flights, $k_н$ = 1,25;

T_{np} - the total run time of a unit of transport equipment, min .;

Q_e - load capacity of one vehicle;

$k_в$ - capacity utilization factor, $k_в$ = 0,8;

$F_д$ is the actual annual operating time of the vehicle, h .;

Total vehicle travel time:

$$T_{np} = T_n + T_з + T_p + T_в$$

where T_n is the vehicle running time at both ends, min .;

$T_з$ - download time, min .;

T_p - time for unloading, min .;

$T_в$ is the time of random delays (approximately 10 % of T_n for each flight), min.

$$T_n = \frac{2 \cdot l}{V}$$

where l is the distance of movement of the vehicle, m;

V - speed of movement of the vehicle, m / min.

The number of bridge cranes can be determined by the formula:

$$K = \frac{N \cdot i \cdot T_{кр}}{m \cdot T_{зм}}$$

N - number of parts to be transported per shift, pc .;

i - the average number of transport operations per item;

$T_{кр}$ - total crane run time, min.;

m is the number of moving parts simultaneously;

$T_{зм}$ - duration of shift, min.

The enlarged number of cranes can be taken: for mechanical shops one crane per 40… 80 m span; in assembly shops - for 30… 50 m.

Development of layout plan for production workshops and sitation

For mechanically assembled workshops, one-story buildings with and without light aeration lamps are used, crane and crane buildings using wheeled and suspended vehicles. In terms of shape, the structures are preferably designed rectangular.

One-story structures account for approximately 85 %% of the total industrial construction, with crane - 20 ... 25 %% and craneless - 60 ... 65 %%. Such buildings are usually more economical multi-storey buildings. One-story buildings have advantages over the placement of equipment due to the availability of larger space, unrestricted frequent frequent placement of columns, with wide possibilities for use of all types of horizontal transport. Accordingly, one-story buildings are used mainly for mechanical engineering enterprises.

One-story buildings can be designed with full or incomplete frame, and with load-bearing walls. In buildings with full frame vertical columns have columns; the outer walls function only as enclosures. In buildings with incomplete frame, the supporting columns are located only inside the building, the outer walls are made bearing, which also perform the function of enclosing structures.

The framework of an industrial building consists of foundations, columns, crane and binding beams. The columns and foundation beams are supported on the foundations. The foundation cut is located at the level of the landmark; the latter is taken at 0.15 m below floor level.

Columns of industrial structures can be reinforced concrete and steel, and their location in the building - medium and extreme. Unique reinforced concrete columns with sections from 400 × 400 to 600 × 1400 mm are used in construction.

The crane beams are intended for placing on them rails of bridge cranes and are made of reinforced concrete or steel. To cover the span and maintain the flooring of the roof are used load-bearing structures, which are most often performed in the form of reinforced concrete farms in machine-building enterprises.

The dimensions of the standard spans and the lifting capacity of the trucks are shown in Table 11.

Table 11 - Dimensions of uniform spans and lifting capacity of trucks

The width of the span, m	Height H of the shop to the lower belt of the farm, m	Height H_1 of the head of the crane rail, m	Type of cranes	Loading capacity of the crane, t
18	6,0; 7,2; 8,4			
24	7,2; 8,4	–	Suspended	0,25…0,30
30	7,2; 8,4			
18	8,4; 9,6	6,15; 6,95; 8,16		
24	10,8			10; 20/5
18			Electric bridges	
24	12,6; 14,4	9,65; 11,45		10; 20/5; 30/5
30				
30 36	16,2; 18,0	12,65; 14,45; 12,0; 13,8	Electric bridges	30/5; 50/10; 75/25
30 36 30	16,2; 18,0; 19,8; 19,8	12,0; 13,8; 15,6; 11,2; 13,0; 14,8	Electric bridges	100/20 150/30

The main dimensions are 144 × 72 and 72 × 72 m with grids of columns 18 × 12 and 24 × 12 m. Wall rows of columns are used in steps equal to 6 m. usually two to four, depending on overall dimensions and placement options. The length of the machine sections and lines for reasons of fire safety is taken not less than 35 ... 50 m, and between them, if necessary, provide main thoroughfares 4.5 ... 5.5 m wide.

Attached and separately located auxiliary administrative buildings are composed of standard type sections characterized by widths of 12 and 18 m, lengths of 36, 48, 60 m, a grid of columns 9 × 6 or 6 × 6 and the number of floors 2, 3, 4. Height of floors is accepted 3,6; 4,2; 6 m

The explanatory note should briefly describe and substantiate the selected structural elements of the building (columns, column foundations, fundamental beams, sling, crane beams, floor slabs, wall panels, light aeration lights, floors and gates).

The initial data for drawing up the layout plan are: the composition of the shop and the area of all offices, the scheme of the building is adopted.

The layout plans of the workshops are carried out on a scale of 1: 100 or 1: 200. In the layout, by means of symbols denote the grid of columns, main walls, main and shop aisles, the boundaries between shops, offices and sections, entrances for railless and rail transport, the main lifting devices (cranes, crane beams, conveyors, etc. e.), basement boundaries, mezzanines, tunnels, passageways and other elements of buildings, indicating the elevation marks for them relative to the first floor, technological dimensions (width and length of spans, column steps, height to crane paths).

The layout plan is accompanied by a cross-section of the span, which is performed on a scale of 1:50 or 1: 100.

The plan is applied coordinate axes, which extend beyond the contour of the image and end with circles in which mark (mark) axes. The horizontal axes of the building in the plan indicate from the bottom up the ordinates in large letters. The vertical axes of the rows of columns are numbered from left to right along the x-axis in successive Arabic numerals. The plan shows the corresponding inscriptions, which indicate the names of workshops, offices, sections and their area.

Planning of equipment placement at production station

The development of the equipment layout plan is a complex and responsible stage of design, when at the same time issues of technological processes, organization of production and economy, production management, safety, choice of vehicles, mechanization and automation of production, scientific organization of work and production aesthetics must be solved.

The following basic requirements should be considered when developing plans:

- equipment in the shop should be placed in accordance with the accepted organizational form of technological processes;

- arrangement of equipment, passageways and passageways should guarantee the convenience and safety of work, the possibility of installation and dismantling of equipment, the convenience of submitting materials and tools, cleaning of waste;

- equipment planning must be consistent with the lifting vehicles used;

- planning should be "flexible", that is, it is necessary to provide for the possibility of relocation of equipment when changing technological processes;

- planning should include jobs for senior engineering and technical staff, and also allow for the use of mechanized and automated accounting and control tools;

- not only the floor space but also the entire volume of the shop and the enclosure should be used rationally when planning.

To carry out the technological planning of the equipment in the drawing of the layout scheme, depicted on a scale of 1:50 for the site, 1: 100 for the shop or 1: 200 for the housing, additionally apply the symbols and projections:

- basic, auxiliary, hoisting and transport equipment, including conveyors of all types and additional equipment, indicating the serial number of the specification, information of the specification, combined with the cost estimate for the purchase and installation of equipment;

- workplaces near the equipment, auxiliary workplaces, multi-peer jobs and routes for servicing their equipment, jobs for site masters and equipment adjusters;

- assembly sites and spare parts for equipment, platforms for storage of materials, semi-finished products or products;

- places of supply of engineering networks (electricity, compressed air, gases, liquids, emulsions, etc.);

- location of devices and devices, such as electrical equipment, sanitary appliances, ventilation, heating;

- location of fire extinguishers, including fire extinguishers, air-foam units, fire shields and fire cocks.

Drawing of equipment planning serves not only the task of developing not only the architectural and construction part of the project, the installation plan of the equipment or the task of designing group or individual foundations for the equipment, but also a source document for the implementation of special parts of the project (ventilation, water supply, sewerage, heating, electrical engineering).), on its basis develop a design project or project of architectural and artistic decoration of the interior of the room, make volumetric models of the object project In addition, they will carry out the feasibility and cost estimates of the project.

Equipment planning is also an initial document for the development of technical tasks for the design of non-standardized equipment, typical jobs, the basis for the use of organizational and technical equipment. On the basis of equipment planning develop or specify schedules and programs of reconstruction (technical re-equipment), schedules of operational management of production during its organization or reorganization.

It has already been noted that in the drawings of technological plans, it is first of all necessary to depict the dimensions of the equipment and the workplaces near this equipment. This kind of work is often preceded by a template layout. For layout planning, it should be borne in mind that, in addition to simple jobs that involve one unit of process equipment and one workplace, complex design jobs are quite common in technological design. These are multi-peer jobs, brigade jobs, and complex jobs from multiple pieces of process equipment connected to a common transportation device, such as an industrial robot. Such robotic complexes or flexible production modules, as well as jobs of peers, require preliminary analytical modeling, calculations and justifications.

Knowing the number of jobs, the structure of simple workplaces and complex technological complexes of equipment, their dimensions and adjusting dimensions of the equipment, it is possible to start designing in order to develop drawings of technological plans.

The basic methods of layout include:

- production of bulk models of equipment;

- obtaining flat orthogonal projections of the equipment, executed on the appropriate scale, - the template method;

- application of CAD technological equipment planning.

When using the template method, you can use both standard and inverse templates (Fig. 1). Inverse templates differ from the standard, that is, large-scale two-dimensional images of equipment or large products on a plane, in that they take into account the dimensions of the workplace near the machine and half the standard distance to adjacent equipment.

Not only is the layout of inverse template layouts more productive than traditional layout methods, but it can also significantly reduce production space losses. Explains such significant savings in production space and the fact that the assembly of inverse templates in the layout of technological plans clearly demonstrates the loss of areas that are clearly visible in the intervals between the templates. Standard templates do not allow such visual evaluations. In addition, when compiling standard templates it is necessary to constantly measure the standards of distances between the equipment, which is not very convenient and requires a lot of labor for the layout. Also, the use of inverse templates can reduce production space losses in some cases by up to 20 %. Template production and development of further drawings of technological plans of the equipment is carried out taking into account such technical requirements and standards of arrangement of technological and lifting and transport equipment.

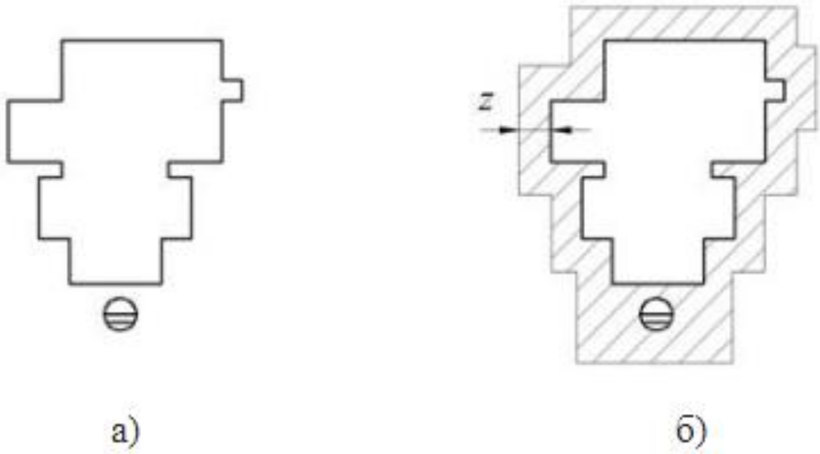

Figure 1 - Standard (a) and inverse (b) templates:
z is half the standard of distance between units of equipment

Norms, that is, the boundary distances between process equipment, machine tools and building elements, widths of passageways and aisles, and other restrictions on the relative location of objects on equipment layouts and technological design drawings, are governed by safety and industrial sanitation rules.

Named distance standards depend on the dimensions of the equipment. They are asked from the extreme positions of moving parts of the equipment, such as from the extreme points of moving tables, from permanent enclosures or barriers to robotics, or from other projecting extremities, including the foundations of equipment.

The norms of placement include places for placement of organizational and technical equipment, areas for storage of blanks near the equipment. Loading and unloading sites at the beginning and end of production lines, as well as assembly sites for large parts, are provided separately. In all cases, the width of the work area near the machine is 800 mm. The workplace is represented by a circle with a diameter of 500 mm in an appropriate scale.

Norms of distances between process equipment can be determined by the schemes of relative location of the equipment.

In the same way, the distances in the projects of foundry, assembly, electroplating and other workshops of enterprises are normalized. Specific data in these cases can be obtained according to the approved standards of technological design of such industries.

The width of passages and passages *B* (2500 <*B* <4000 ... 6000), in addition to the main passages, is equal to:

$$B = n \cdot H + w(Z + T),$$

where *n* is the number of working areas (*n* = 1 for single row, *n* = 2 for double row equipment);

H - width of the working area (800 mm);

w - number of directions of freight flows in transit (1 or 2 oncoming);

Z - guaranteed clearance between the vehicle and the working area (200 mm in the case of using electric cars or carts and 0 in the case of rolling shutters, slopes, slides and other stationary continuous vehicles);

T is the width of the vehicle (provided that the goods it transports do not exceed its dimensions).

As a general comment on the use of these standards, it should be noted that at different sizes of the two machines located next to each other, the distances between them take on a larger value of the standard. In the case of machine tools for bridge or other overhead cranes, distances from walls and columns to the machines are taken into account taking into account the possibility of servicing the process equipment at the extreme position of the crane hook.

Machines may be mounted close to the walls or assembled into blocks. The press is set according to the standards of distances, the value of which depends on the effort of the press and the presence of the foundation.

Modeling of technological equipment for justification of drawings of technological plans allows:

- placement of models of trucks, especially ground-based;
- layout or designation of building elements;
- placement of models of large-sized power equipment: boards, consoles,

transformer booths, hydraulic units, compressors (small-sized equipment - lamps, places of supply of electricity, etc. are usually depicted with icons on templates or volumetric layouts);

- placement of layouts of sanitary appliances, fire extinguishers and other devices.

The most effective method of developing site plans and workshops is bulky layout, which is based on the use of bulk models of equipment, transportation systems, building elements and more. The application of this method allows to place spatially transport and technological equipment in the building and, thus, to prevent a number of errors with placement in height and in space, which cannot be foreseen in the plane formation of plans.

During the implementation of the equipment layout, all the above principles of layout of the production units should be fulfilled, as well as minimizing not only the required production space, but also the turnover, meeting the requirements of compatibility of the adjacent production units, such as fire and explosion criteria, noise level, environmental noise and environmental standards. other technical requirements of modern production organization.

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