

TOMSK POLYTECHNIC UNIVERSITY

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MACHINE SHOPS DESIGN

LABORATORY WORKS

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Laboratory work № 1

Drawing a shop floor layout not to scale

Goal: to acquire skills of drawing a shop floor layout.

Equipment:

1. A sheet of squared paper or graph paper (format A4);
2. A pencil;
3. An eraser;
4. A ruler;
5. A tape measure (not less than 3 m).

Laboratory work procedure:

1. Specify the boundaries of the shop floor of the existing industry and its proportions (a proportion of its length and width). If it is difficult to determine shop floor proportion visually, you should pace it out. Incorrectly determined proportions will not allow you to draw a layout correctly!
2. On a sheet of squared paper or graph paper draw the shop floor contours in proportion by a pencil with a thin line paying attention to the layout of the basic structural elements (doors, windows, columns, partitions, etc.). It is necessary to mark these elements on the sheet when drawing the shop contours by keeping their positional relationship on the opposite walls. You should draw wing doors, windows, doors of built-in cupboards in open position.
It will be better if you define a scale before drawing the contours. Usually it is a scale of 1:50 for small shop floors (up to 120 m² or, what is more correct, with the maximum (limiting) side: across the width – up to 9 m, along the length – up to 14 m, so that it can be possible to draw on the sheet of A4 format); 1:100 for medium-size shop floors (from 120 m² to 500 m², or across the width – up to 18 m, along the length – up to 28 m); 1:200 for large shop floors. If a sheet of bigger size is used for representing a layout, it is desirable to use the maximum scale, for example, 1:50.
3. For convenience divide the existing shop floor into rectangular or square parts (there can be 4, 6, 8, 10, etc. parts) attaching to the structural elements. The bigger the shop floor area is and the more

complex its configuration is, the more parts it may have. We put this grid on the sheet with the shop floor contours.

4. Draw contours of the equipment and others objects available in the place (cabinets, tables, chairs, etc.) with a thin line by the pencil on the sheet with the accepted proportions of the place (in approximate scale), keeping its position in relation to the structural elements and conditional grid. Wing doors of the equipment, control cabinets, etc. should be drawn in open position.

If the object is located at an angle to a wall, it is required to specify the distances from the nearest (relative to the walls, columns, etc.) point of object body frame and, in addition, to specify the angle of the object axis relative to the nearest wall. It is usually specified what point of the opposite wall this axis is directed to.

When drawing contours of the equipment and objects it is necessary to pay special attention if the width of passages and distances between the neighbouring objects correspond to the nearest structural elements. Thus designers usually use human proportions: its width (approximately 600 mm), arm span (approximately 1700 – 1800 mm, i.e. arm span is approximately equal to the person's height).

5. After representing all the objects in the shop floor with a thin line, check up if the drawn equipment layout corresponds to the actual one. If it is necessary, make corrections.
6. It is necessary to write an object name or machine tool model on all drawn objects. For example, C (a cabinet), 1K62 (a lathe model), PC1 (power cabinet № 1), T (a table), CRC (a chip-receiving container), AB (an area for placing blanks), AP (an area for placing parts (blanks processed on the considered machine tool)), PuC (a push cart), FW (foreman's workplace), S (sink), etc. It is necessary to write "*Entrance*" for the entrance door as well as to specify all emergency exits "*Emergency exit № __*" (if they exist). It is necessary to write full forms of the identification codes in alphabetic order on a separate sheet (specification).
7. On the sheet with the equipment layout specify the sizes which it is necessary to measure with a tape measure. They are: the length and width of the shop floor and all its departments (for a place with complex configuration); the height of the shop floor and all of its departments, if their height is different; the width of windows, doors,

columns and the distances between the neighbouring structural elements (between the neighbouring windows, between the door and walls, etc.); overall dimensions of all the objects which are located in the shop floor; the distance from the objects to the nearest structural elements as well as between the neighbouring objects. All this data will be necessary for performing a lay-out to scale.

8. Measure with a tape measure the required sizes and write them on the layout above the prespecified dimension lines.
9. Outline the contours of the shop floor and objects with a thick (basic) line.
10. Hand in the report to be checked.

References:

1. Козлов В.Н. Проектирование механосборочных цехов. Учебное пособие.– Томск, Изд. ТПУ, 2009 г. – 144 с.
2. Мельников Г. Н., Вороненко В. П. Проектирование механосборочных цехов. М.: Машиностроение, 1990. – 350 с.
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5. Петкау Э. П., Матвеев В. С., Журавлев В. А. Проектирование машиностроительного производства: Учебное пособие. – Томск: Изд-во ТПУ, 2002. 199 с.
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Laboratory work № 2

Performing a shop floor layout to scale

Goal: to receive skills of performing a shop floor layout to scale.

Equipment:

1. A sheet of squared paper or graph paper (format A4);
2. A pencil;
3. An eraser;
4. A ruler;
5. A tape measure (not less than 3 m).
6. A shop floor layout performed not to scale (the report on laboratory work № 1).

Laboratory work procedure:

1. Specify the scale in which the layout will be carried out so that the maximum size of the shop floor can be fitted into the sheet. Besides, on the sheet with the future layout there should be some place reserved for a frame and title block
Usually it is a scale of 1:50 for small shop floors (up to 120 m² or, what is more correct, with the maximum (limiting) side: across the width – up to 9 m, along the length – up to 14 m, so that it can be possible to draw on the sheet of A4 format); 1:100 for medium-size shop floors (from 120 m² to 500 m², or across the width – up to 18 m, along the length – up to 28 m); 1:200 for large shop floors. If a sheet of bigger size is used for representing a layout, it is desirable to use the maximum scale, for example, 1:50.
2. Draw the shop floor contours and basic structural elements in accordance with the accepted scale.
3. Draw contours of all the objects according to the accepted scale. If it is necessary, measure the wanting sizes with a tape measure and represent them on the performed layout (see the report on laboratory work № 1).
4. Write numbers on the object images which will correspond to the object names in the specification attached to the layout. Specify the numbers on object images in accordance with the count (beginning with 1), first start from the top from left to right, and then one line

below from left to right, etc. If the considered object has already been specified on the layout, it is given the same number and the specification will contain the information about the quantity of such objects on the shop floor layout.

5. Specify the sizes of the shop floor, the width of the entrance door and emergency exits, overall dimensions of all departments (for example, the tool-grinding department, the training department, etc.), the distance between machine tools and from walls to machine tools, the width of the aisle ways on the layout.
6. Fill in the specification.
7. Hand in the report to be checked.

References:

1. Козлов В.Н. Проектирование механосборочных цехов. Учебное пособие.– Томск, Изд. ТПУ, 2009 г. – 144 с.
2. Мельников Г. Н., Вороненко В. П. Проектирование механосборочных цехов. М.: Машиностроение, 1990. – 350 с.
3. Проектирование машиностроительных заводов и цехов: Справочник. В 6 т./Б. И. Айзенберг, М. Е. Зельдис, Ю. Л. Казарновский и др. М.: Машиностроение, 1974, 1975.
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Laboratory work № 3

Analyzing a shop floor layout

Goal: to receive skills of analyzing a shop floor layout and conforming to design norms.

Equipment:

1. A shop floor layout made by another student to scale (the report on laboratory work №2);
2. A ruler;
3. A tape measure (not less than 3).

Laboratory work procedure:

1. Define if the performed layout corresponds to the existing layout of the equipment. Special attention should be given to the object layout in relation to the neighbouring objects and the nearest structural elements. It is necessary to make a conclusion for each object and structural element.
2. Check up the specified sizes (selectively), if there is some discrepancy, make remarks;
3. Assess the general impression of the performed layout;
4. Check up if the specified distances between machine tools and structural elements conform to construction code and regulations. If there is some discrepancy, make remarks;
5. Hand in the report to be checked.

References:

1. Мельников Г. Н., Вороненко В. П. Проектирование механосборочных цехов. М.: Машиностроение, 1990. – 350 с.
2. Проектирование машиностроительных заводов и цехов: Справочник. В 6 т. /Б. И. Айзенберг, М. Е. Зельдис, Ю. Л. Казарновский и др. М.: Машиностроение, 1974, 1975.
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Laboratory work № 4

Performing a shop floor layout to scale conforming to design norms

Goal: to receive skills of performing a shop floor layout to scale conforming to design norms.

Equipment:

1. A sheet of squared paper, graph paper (format A4) or Whatman paper;
2. A pencil;
3. An eraser;
4. A ruler;
5. A tape measure (not less than 3 m).
6. A shop floor layout performed to scale (the report on laboratory work № 2).

Laboratory work procedure:

1. Specify the scale in which the layout will be carried out so that the maximum size of the shop floor can be fitted into the sheet. Besides, on the sheet with the future layout there should be some place reserved for a frame and title block.
2. Draw the shop floor contours and basic structural elements in accordance with the accepted scale.
3. On a separate sheet of Whatman paper draw the contours of each object which are on the old shop floor layout to the accepted scale. Cut out a template, write the name of the object on it.

4. Put the cut templates on the sheet with scale shop floor contours and find the optimum variant from the view point of filling the minimum area without breaking design norms.

Place the equipment in order of performing the part-representative master schedule.

The first operation is usually performed on the left of the entrance (as a rule, the storehouse for blank is located there) and closer to a longitudinal wall.

After determining the optimum variant of the equipment arrangement, the templates are outlined by a pencil with a thin line. The equipment contours are thoroughly outlined after finishing the whole shop floor layout.

Write numbers on the object images which will correspond to the object names in the specification attached to the layout (these numbers, as a rule, will not coincide with those written on the templates).

Specify the numbers on object images in accordance with the count (beginning with 1), first start from the top from left to right, and then one line below from left to right, etc. If the considered object has already been specified on the layout, it is given the same number and the specification will contain the information about the quantity of such objects on the shop floor layout.

5. Specify the sizes of the shop floor, the width of the entrance door and emergency exits, overall dimensions of all departments (for example, the tool-grinding department, the training department, etc.), the distance between machine tools and from walls to machine tools, the width of the aisle ways on the layout.
6. Fill in the specification.
7. Hand in the report to be checked.

References:

1. Мельников Г. Н., Вороненко В. П. Проектирование механосборочных цехов. М.: Машиностроение, 1990. – 350 с.
2. Егоров В. А. Автоматизация проектирования предприятий. Л.: Машиностроение, 1983. – 327 с.
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Laboratory work № 5

Calculating labour input to process the annual program of all parts in the shop

Goal: to acquire skills of calculating labour input of the annual program to machine all parts in the shop.

Raw data:

1. Drawings of the parts machined in the shop during 1 year with the annual production program.

Equipment:

1. A calculator;
2. An eraser;
3. A ruler;
4. A pencil.

Laboratory work procedure:

1. Sort the drawings of the parts machined in the shop within 1 year into groups in accordance with their constructive and technological similarity;
2. Draw the complex part for each group containing surfaces which are typical for the group of parts under consideration;
3. On the drawing of the complex part it is necessary to specify mid-of-tolerance sizes and required processing accuracy, roughness and surface-to-surface accuracy which are typical for the considered group of parts. The annual program is equal to the biggest annual program among all parts of the group;
4. Make a manufacturing route of the complex part, the required equipment (machine tool model) for each operation and an operational sketch of processing.
5. Specify cutting tools, feed rate, calculate cutting speed and operation time for all machining passes of each operation;
6. Determine the batch size for the complex part and calculated floor-to-floor time for each operation, calculated floor-to-floor time for the

whole manufacturing process, write down the results of calculation in Table 1;

7. Calculate reduction factors for all parts of the considered group, write down the results of calculation in Table 1;
8. Calculate labour input of *one part* to process each part of the considered group. Make a calculation in accordance with the reduced program;
9. Calculate total labour input of *the annual program* to process all parts of the considered group.
10. Suppose that processing of parts of other groups will be carried out in other shops.
11. Hand in the report to be checked.

Table 1

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

№ of part	Weight of part, kg	Reduction factor on weight, $K_{w,j}$	Annual production program, N_j , pieces	Reduction factor on seriality, $K_{s,j}$	Average grade of tolerance and accuracy factor $K_{a,j}$	Average surface roughness, R_a , microns, and roughness factor $K_{Ra,j}$	Reduction factor on complexity, $K_{c,j}$	Total reduction factor, $K_{r,j}$	Labour input of manufacturing one part j , $T_{c.f.,j}$, minutes	Labour input of annual program for manufacturing part j , $T_{N.c.f.,j}$, minutes
<i>I</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>	<i>8</i>	<i>9</i>	<i>10</i>	<i>11</i>
0	5	1	1000	1	8→1.5	2.5→1.1	1	1	20.6	Calculation is not required
1	7	1.25	500	1.12	11→1.0	10→0.9	0.66	0.924	19.03	9517.2
2	5	1	1000	1	8→1.5	2.5→1.1	1	1	20.6	20600
3	7	1.25	500	1.12	8→1.5	2.5→1.1	1	1.4	28.84	14420
4	5	1	1000	1	7→2.0	2.5→1.4	1.7	1.7	35.02	35020
5	7	1.25	500	1.12	7→2.0	2.5→1.4	1.7	2.38	49.03	24514
6	2	0.54	2000	0.97	11→1.0	10→0.9	0.66	0.35	7.12	14240
7	7	1.25	500	1.12	11→1.0	10→0.9	0.66	0.924	19.03	9517.2
...
<i>j</i>	7	1.25	500	1.12	8→1.5	2.5→1.1	1	1.4	28.84	14420
Total: $T_{\Sigma N.c.f.} = \Sigma T_{N.c.f.,j}$										50620 hrs.

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

References:

1. Козлов В.Н. Проектирование механосборочных цехов. Учебное пособие. – Томск, Изд. ТПУ, 2009 г. – 144 с.
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Laboratory work № 6

Calculating equipment quantity and production floor space

Goal: to receive skills of calculating equipment quantity and production floor space to process the annual program of all parts in the shop for small-scale manufacture.

Raw data:

1. Drawings of the parts processed in the shop within 1 year, with the annual program of output;
2. Annual labour input to process each part (from the report on laboratory work №5);
3. Technological process of machining the complex part indicating a machine tool model and calculated floor-to-floor time for each operation to process one complex part (from the report on laboratory work №5).

Equipment:

1. A calculator;
2. An eraser;
3. A ruler;
4. A pencil.

Laboratory work procedure:

1. Define operations in which the same model of the machine tool is used in accordance with the technological process to machine the complex part. Calculate total calculated floor-to-floor time to process one complex part for each model of the machine tool, write down the results of calculation in Table 1;

For example:

Table 1

Calculation of labour input for small-scale manufacture

Model of machine tool	Number (name) of a part	Numbers of operations (j), №	Summing-up calculated floor-to-floor time $t_{c.f.}$ of operations using the same model of the machine tool $\Sigma t_{c.f.j}$, minutes
1	2	3	4
16K20	complex part	1, 2, 5, 7	$2+1.2+3.3+4=11$
6H82	complex part	3, 6	$4.2+5.1=9.3$
2125	complex part	4	1.3
Labour input of machining one part, $T_{c.f.}$, minutes			$T_{c.f. \text{ complex}} = 20.6$

2. Calculate the level of equipment use α_{m-t} for each model of the machine tool;

For example:

$$\alpha_{16K20} = \sum t_{c f 16K20} / T_{c.f. complex} = 11/20.6 = 0.53;$$

$$\alpha_{6H82} = \sum t_{c f 6H82} / T_{c.f. complex} = 9.3/20.6 = 0.45;$$

$$\alpha_{2125} = \sum t_{c f 2125} / T_{c.f. complex} = 1.3/20.6 = 0.06.$$

$$\text{Verification: } \sum \alpha_{m-t} = 0.53 + 0.45 + 0.06 = 1.04 \approx 1.$$

3. Calculate the required quantity of the equipment of each model of the machine tool to process the annual program of all parts in the shop (calculated $C_{c m-t}$ and accepted $C_{ac m-t}$ quantity);

For example:

$$C_{c 16K20} = C_c \times \alpha_{16K20} = 12.5 \times 0.53 = 6.6 \text{ pieces; } C_{ac 16K20} = 6 \text{ pieces}$$

(overtime will be equal to 10 %).

$$C_{c 6H82} = C_c \times \alpha_{6H82} = 12.5 \times 0.45 = 5.6 \text{ pieces; } C_{ac 6H82} = 6 \text{ pieces.}$$

$$C_{c 2125} = C_c \times \alpha_{2125} = 12.5 \times 0.06 = 0.75 \text{ pieces; } C_{ac 2125} = 1 \text{ piece}$$

The total quantity of accepted machine tools is calculated in such a way:

$$C_{ac tot} = \sum C_{ac m-t} = 6 + 6 + 1 = 13 \text{ pieces.}$$

4. Calculate the required production floor space for the shop to place the accepted quantity of machine tools;

The total production floor space

$$S_m = \sum_{i=1}^n C_{ac,i} \times f_i ,$$

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

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

For small machine tools $f = 7 \dots 10 \text{ m}^2$ /machine tool;

For medium machine tools $f = 10 \dots 20 \text{ m}^2$ /machine tool;

For large machine tools $f = 20 \dots 60 \text{ m}^2$ /machine tool;

For very large machine tools $f = 60 \dots 170 \text{ m}^2$ /machine tool.

In our example we suppose that specific production area is the same for all machine tools and we deal with medium size machine tools and a small shop (cell or site), consequently the specific production area is maximum in the considered group of medium size machine tools:

$$S_m = C_{ac\ tot} \times f = 13 \times 20 = 260 \text{ m}^2.$$

5. Define the optimum arrangement of the production equipment in the shop and calculate the optimum width, and then length of the production department according to the required production floor space;
6. Make an equipment layout in accordance with the accepted arrangement and calculated width of the shop;
7. Hand in the report to be checked.

References:

1. Козлов В.Н. Проектирование механосборочных цехов. Учебное пособие.– Томск, Изд. ТПУ, 2009 г. – 144 с.
2. Мельников Г. Н., Вороненко В. П. Проектирование механосборочных цехов. М.: Машиностроение, 1990. – 350 с.
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6. Королёва Н. И. Организация производства на предприятии: Учебное пособие. – Томск: Изд-во ТПУ, 2005. 156 с.
7. Wawa H.S. Workshop practice (2nd edition). Published by Tata McGraw Hill. 2009

Laboratory work № 7

Designing a tool management system

Goal: to receive skills of designing a tool management system.

Raw data:

1. Drawings of the parts processed in the shop within 1 year, with the annual program of output;
2. Annual labour input of processing each part of the group (from the report on laboratory work №5);
3. Technological process of machining the complex part indicating the machine tool model and calculated floor-to-floor time for each operation to process one complex part (from the report on laboratory work №5);
4. The quantity of machine tools of each model in the shop (from the report on laboratory work №6);
5. Operation sheets of the parts processed in the shop within the specified period (2 shifts) for each machine tool with the specified batch workpieces.

Equipment:

1. A calculator;
2. An eraser;
3. A ruler;
4. A pencil.

Laboratory work procedure:

1. Define the name and basic parameters of cutting and measuring tools, machining attachments which will be used to perform operations in accordance with the operation sheets for processing parts (or the complex part) processed in the shop within the specified period;
2. Calculate labour input of processing parts on each machine tool within the specified period;
3. Calculate the time for continuous work of the tool of each name for each machine tool, required quantity of tools in accordance with the cutting tool life accepted at metal-cutting calculation (from the report on laboratory work №5);

4. Calculate the required area of the tool storage room supposing that the same tools will be used at the same wear rate during one month;
5. Hand in the report to be checked.

References:

1. Мельников Г. Н., Вороненко В. П. Проектирование механосборочных цехов. М.: Машиностроение, 1990. – 350 с.
2. Козлов В.Н. Проектирование механосборочных цехов. Учебное пособие. – Томск, Изд. ТПУ, 2009 г. – 144 с.
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Educational Edition

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ПРОЕКТИРОВАНИЕ МЕХАНОСБОРОЧНЫХ ЦЕХОВ

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