

METHOD OF CALCULATION THE NUMBER OF DIMENSIONS

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Abstract. This research work is located within the present context of raising standards in engineering education through the quality of teaching improvement. It is connected with preparation of competent and qualified engineers who are required at the Latvian labour market today. Engineering is the applied science of acquiring and applying knowledge to design analysis and work construction for practical purposes. Engineering is the subject that ranges from large collaborations to small individual projects. In any case a project has to be concrete; it must have its geometry, dimensions and other characteristics according to the basic rules of the technical drawing construction and performance. It is known that such a theme as "Dimensioning" is the thing of a great difficulty for students because they must learn the basic rules of dimensioning, the technology of mechanical parts production and the ways of their control; as well as be able to use theoretical knowledge in practical work. Development of dimensioning skills is a necessary stage in the process of learning technical graphics. The aim of the work is students' knowledge on the theme "Dimensioning" systematization, in particular, the research of the number of dimensions depending on the way of their placing and the kind of the part's production. The author of the article states the conception of an opportunity to calculate the number of dimensions in the technical drawing of a mechanical part. As a result, the method of the number of dimensions calculation was created. This method gives an opportunity to calculate the number of dimensions in the part's drawing before dimensioning quickly and correctly. It is necessary to note that the total number of dimensions for any part does not depend on the kind of technological treatment and the way of dimension placing. Application of this method raises students' learning activities in the process of studying the theme "Dimensioning". Correctly and rationally marked dimensions ensure good quality of the manufactured products.

Key words: engineering education, teaching quality, learning activity, technical drawing, dimension's number.

Introduction

"Scientists study the world as it is; engineers create the world that has never been."

Theodore von Kármán (1881-1963)

Engineering is quite different from science. One who practices engineering is called an engineer. Scientists try to understand nature. Engineers try to make things that do not exist in nature. Engineers stress invention. To embody an invention the engineer must put his idea in concrete terms, and design something that people can use. That something can be a device, a gadget, a material, a method, a computing program, an innovative experiment, a new solution to a problem, or an improvement on what is existing. Since a design has to be concrete, it must have its geometry, dimensions, and characteristic numbers. There are many branches of engineering, such as Electrical and Electronics engineering, Machinery and Safety, Communications and Control, Computers, Mechanical engineering, etc.

Mechanical engineering is the branch of engineering that specializes in the design, production, and uses of machines. It is divided into, firstly, in machinery, mechanisms, materials, hydraulics, and pneumatics, and, secondly, heat as applied to engines, work and energy, heating and cooling systems, ventilating, air conditioning and more. A mechanical engineer designs not only the machines that make products but the products themselves, and must design for both economy and efficiency. In higher education engineering is a technology-based study subject that aims to develop students' technical skills and knowledge in an Engineering context. In the theory component of the course students study such disciplines as mathematics, physics, metal-joining processes, polymers, materials testing, manufacturing processes, mechanics, hydraulics, machine design, electronics, mechanisms, technical graphics, etc.

Technical graphics develops creativity and spatial awareness by getting the students to reason in two and three dimensions. It helps students to communicate their ideas graphically and allows them to experiment with shape and form, shade and color. The most important object of the technical graphics

is the technical drawing of the mechanical part. Technical graphics is the international language of engineering. As once G. Monge said, "Technical drawing is a graphical language of engineering" [1]. It gives students a unique way of communicating. It imparts the ability to imagine and mentally manipulate spatial forms. Students present their ideas and solutions in the form of drawings. It is their means of developing and recording their ideas, and conveying them to others. Every engineer will be using and referring to some form of drawings almost daily. They will often be producing or directing the preparation of drawings. Usually, they make the preliminary sketches and design drawings in accordance with principles of engineering drawing. Because this is the most unambiguous way of to convey and record information. It is also likely that every engineer at sometime will be checking the work of designer drafters and approving drawings before they are sent to manufacturing. When engineers sign off the final approval of a drawing, they take responsibility for it. An overlooked error in the drawing could be costly. Ideally, then, engineers should be good draftspersons. They can constructively criticize the work of inexperienced drafters. However, with the limited time available at the university it is not possible to get the necessary proficiency. It is important to notice that technical drawings are also required for disciplines that would not ordinarily be thought of as parts of engineering. But in engineering approximately 90 % of the projects are based on graphical part. In this way, engineering education is based on the graphical activity.

Technical drawing is the means by which mechanical engineers create instructions for manufacturing parts. Therefore, a technical drawing should satisfy the following requirements:

- It should be visual, i.e. it should cause *visual* perception of the object's image.
- It should be *reversible*, i.e. it should give an opportunity to reproduce the shape and the size of the object's image.
- A technical drawing should be sufficiently *simple* from the point of view of its graphic construction.
- Graphic operations should lead to *preciseness* of the technical drawing construction.

Technical drawings contain the following necessary information:

- *Geometry* – the shape of the part; represented as views; how the part will look when it is viewed from various standard directions, such as front, top, side, etc.
- *Dimensions* – the size of the part is captured in accepted units.
- *Tolerances* – the allowable variations for each dimension.
- *Material* – represents what the part is made of.
- *Finish* – specifies the surface quality of the part, functional or cosmetic. For example, a mass-marketed product usually requires a much higher surface quality than, say, a component that goes inside industrial machinery.

One of the most complicated themes in the content of "Technical Graphics" is indicating dimensions in technical drawings of mechanical parts. Dimensions should to reflect manufacturing and construction practices, it is not an isolated exercise in placing numbers on a technical drawing. When dimensioning it is necessary to be guided by the basic rules, ways of placing dimensions, which represent general dimensioning practice as prescribed by LVS EN ISO (Latvian State Standards).

The essence of the method of calculating the number of dimensions

Firstly, the essence of the method of calculating the number of dimensions is based on the main rules of dimensioning. Secondly, it is based on the hypothesis of calculating the number of dimensions for any mechanical part in order to ensure that it improves the quality of teaching, promotes learning activities and helps students to develop their knowledge, abilities and skills.

Before a technical drawing is made, the basic rules of indicating dimensions should be reviewed [2-9]. Apart from these rules, there are several peculiarities relating to indicating dimensions in technical drawings of parts, because, if a part is to be produced, the necessary dimensions are indicated taking into consideration the possible technology process and providing convenient control.

There are three ways of placing dimensions: coordinate, chain and mixed. According to coordinate way dimensions are coordinates which characterize the situation of elements of a part in

respect of one and the same base (surface) of a part (Fig. 1 a). Using chain way dimensions of separate element of a part are placed in succession as links of one chain (Fig. 1 b).

Mixed way is a combination of coordinate and chain ways (Fig. 1 c). As Fig. 1 shows, it is obvious that the total linear dimension number of the part which are parallel to the X axis is the constant value ($K_{lx} = 4$), and it does not depend on the way of placing dimensions.

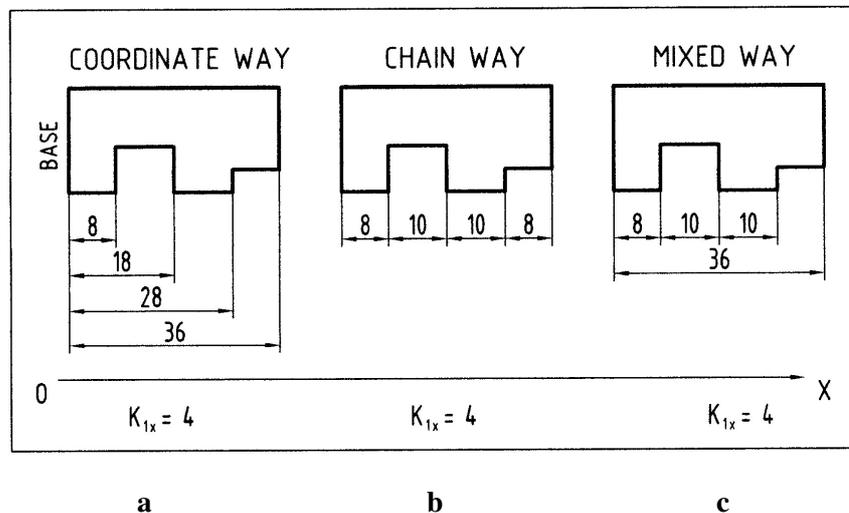


Fig.1. The number of dimensions for plane part according to the ways of dimensions placing

Let's have a good look at the parts of the same shape which were made in a different way, for example, turning (Fig. 2 a) and casting (Fig. 2 b). As Fig. 2 shows, the linear dimension number of these parts is the same value ($K_{lx} = 2$), and, as we can see, it does not depend on the way of the parts' making [10, 11].

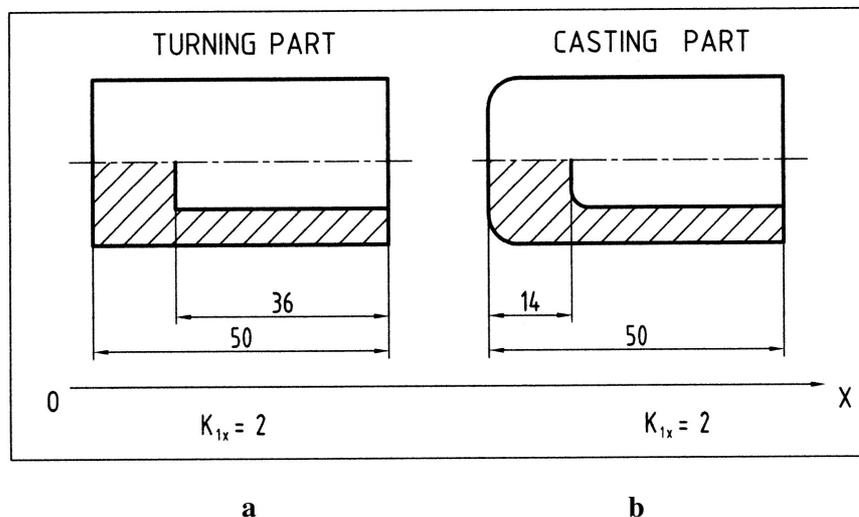


Fig. 2. The number of dimensions for turning part and for casting part

As noted early, it is possible to calculate the number of dimensions precisely [12].

The number of dimensions of a part is determined by the dimensions of separate elements. For this purpose, all dimensions should be divided into two groups. They are:

- *Linear dimensions* (length, width, height, depth, distance between the centres of orifices etc.).
- *Form dimensions*, which are designated by conventional symbols (\emptyset – diameter, R – radius, \square – square, s – thickness, $^\circ$ – angle, O – sphere etc.).

It should be mentioned that the total number of dimensions for any part is

- constant value;
- independent of the way of placing dimensions;

- independent of the kind of production technology;
- and is equal to

$$K = K_1 + K_2, \tag{1}$$

where K_1 – number of dimensions of group 1;
 K_2 – number of dimensions of group 2.

In its turn,

$$K_1 = K_{1x} + K_{1y} + K_{1z}, \tag{2}$$

$$K_{1x} = M_{1x} - 1, \tag{3}$$

$$K_{1y} = M_{1y} - 1, \tag{4}$$

$$K_{1z} = M_{1z} - 1, \tag{5}$$

where K_{1x} – number of dimensions in the direction of X axis (length);
 K_{1y} – number of dimensions in the direction of Y axis (width);
 K_{1z} – number of dimensions in the direction of Z axis (height);
 M_{1x} – number of lines, which are perpendicular to the X axis or to the length of a part;
 M_{1y} – number of lines, which are perpendicular to the Y axis or to the width of a part;
 M_{1z} – number of lines, which are perpendicular to the Z axis or to the height of a part.

$$K_2 = N, \tag{6}$$

where N – the number of elements which should be designated by conventional symbols.

Fig. 3 exemplifies the determination of the dimension number for a spatial non-symmetrical part. The following data indicated in the Fig. 3: part “a” contains the projections of the spatial non-symmetrical part with marked lines to calculate the number of dimensions; part “b” – the number of lines and appropriate number of dimensions in table form; part “c” – the technical drawing of the spatial non-symmetrical part with all its necessary dimensions.

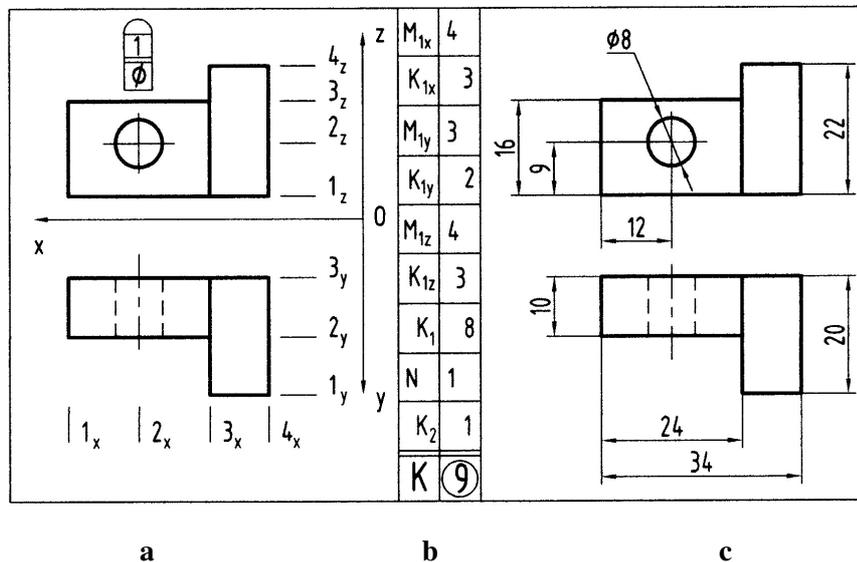


Fig. 3. The number of dimensions for a spatial non-symmetrical part

Notes

1. For a flat non-symmetrical part

Dimension's number calculate, as it is shown in the Fig. 4.

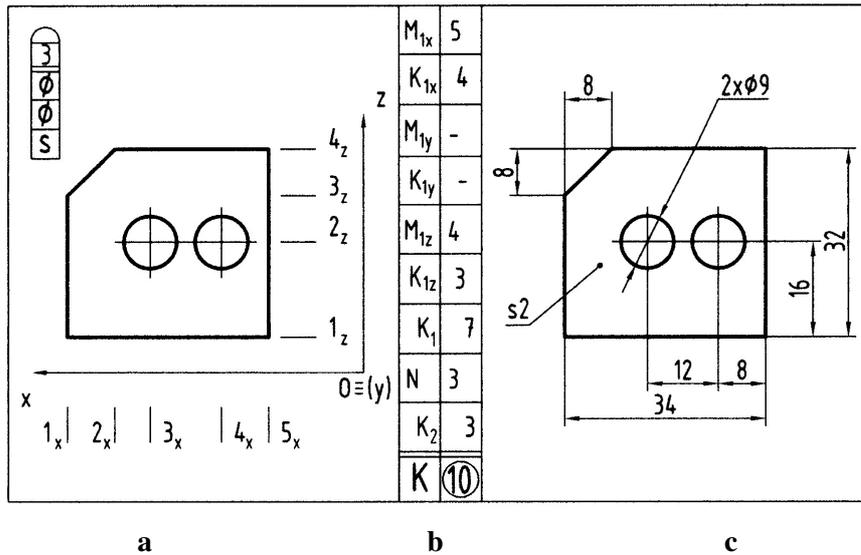


Fig. 4. The number of dimensions for a flat non-symmetrical part

2. For a symmetrical flat part

As Fig. 5 shows, M_{11} – is the number of lines which are perpendicular to the symmetric axis SA, M_{12} – is the number of pairs of lines which are parallel to the symmetric axis SA, i.e., $K_{11} = M_{11} - 1$, $K_{12} = M_{12}$. The number of linear dimensions K_1 is equal to $K_1 = K_{11} + K_{12}$. The number of form dimensions is equal to $K_2 = N$. Thus, the total number of dimensions for a symmetrical flat part is equal to $K = K_1 + K_2$.

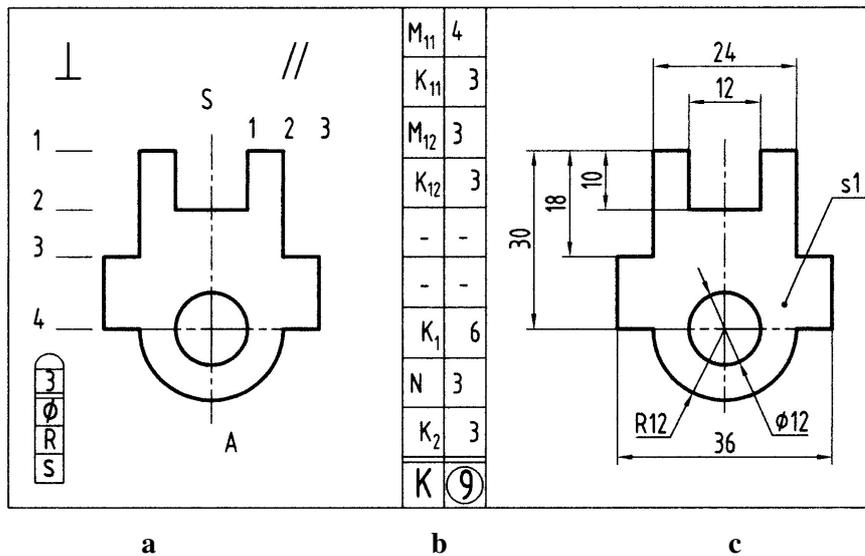


Fig. 5. The number of dimensions for a flat symmetrical part

3. For a symmetrical cylindrical part

As it can see from Fig. 6, M_1 is the number of lines which are perpendicular to the symmetry axis SA and M_2 is the number of pairs of lines which are distributed along the symmetry axis SA, i.e., the number of dimensions which need conventional symbols. Thus, the number of linear dimensions is equal to $K_1 = M_1 - 1$. The number of form dimensions is equal to $K_2 = M_2$. Thus, the total number of dimensions for a symmetrical flat part is equal to $K = K_1 + K_2$.

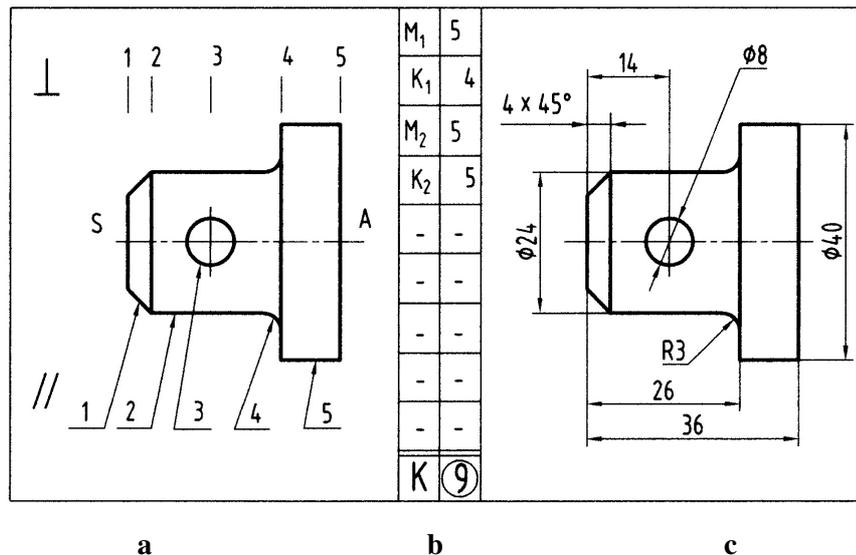


Fig. 6. The number of dimensions for a symmetrical cylindrical part

It is important to notice that the worked out method of calculation of dimensions number is neither included in the standard nor described in textbooks.

Conclusions

The author of the article "Method of calculating the number of dimensions" analyses the significance of technical drawings in engineering education.

1. The research shows that the content of the theme "Dimensioning" in study course of technical graphics is very important but difficult for students.
2. In order to enrich students' knowledge and skills on the theme "Dimensioning", as well as to improve the quality of teaching and promote learning activities, it is necessary to use a creative approach, choose the most effective teaching methods and solve pedagogical problems creatively.
3. As a result, the method of calculating the number of dimensions in technical drawings of mechanical parts was created. This method is based on the main rules of dimensioning and it enables to calculate the total number of dimensions independently of the way of dimension placing and the kind of production technology.

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