GALAXY INTERNATIONAL INTERDISCIPLINARY RESEARCH JOURNAL (GIIRJ)
ISSN (E): 2347-6915
Vol. 10, Issue 2, Feb. (2022)

ABOUT THE PROBLEMS OF ENSURING THE ACCURACY OF THE RELATED POSITION OF PARTS SURFACES DURING PROCESSING

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ANNOTATION

The article deals with the issues of ensuring the accuracy of the relative position of the surfaces of the part. It is noted that the existing regulatory documents do not allow to unambiguously and correctly set the dimensions and parameters of the relative position of the surfaces in the drawing. It is shown that the main problems arising in the process of technological preparation are associated with the ambiguity, incorrectness and inefficiency of specifying requirements for the relative position of surfaces on the drawings.

Keywords: mutual arrangement of surfaces, design and technological preparation, basing schemes, dimensional chains.

INTRODUCTION

The accuracy of the mutual arrangement of cylindrical parts includes radial runout, misalignment, fluctuations in the distance between the axes, non-parallelism, crossing and non-perpendicularity of the axes, the accuracy of the location of the holes. If technically necessary, the drawing should limit the corresponding deviations.

When designing the process of machining parts, it is necessary to solve three main technological problems:

• Determination of methods for providing a geometric shape for each machined surface;

• Determination of the conditions (methods) for ensuring the relative position of the surfaces of the part,

• Determination of the method of separating the material from the workpiece.

The listed tasks are solved at the stage of design and technological preparation of production. At the same time, it is important to form (construct) the geometric image of the part in such a way that, on the one hand, its full functionality is ensured, and, on the other hand, the possibility of its rational manufacture under given production conditions. In other words, in the process of designing the configuration of a part, it is highly desirable to ensure, if not the best, then close to that manufacturability of its manufacture.

And although the current state of science does not allow this due to the lack of formal methods for the synthesis of options and their optimization, the existence of an unambiguous relationship between the geometric configuration of the part (the shape of the surfaces and their relative position) and its technological properties (parameters and characteristics) has been revealed [1].

According to GOST 2.101-68, a part is a product made from a homogeneous structure and material properties, without the use of assembly operations [2]. The geometric configuration of

parts can be represented as a set of simple infinitely extended surfaces, for example, a cylinder, sphere, plane, etc., and the relationships between them.
The article deals with the problems associated with only one of the specified technological tasks - Ensuring the accuracy of the relative position of the surfaces of the part.
As you know, the accuracy of the relative position of the surfaces is determined by the set of requirements specified in the drawings, in the form of the so-called "coordinating" dimensions.
An analysis of the requirements for the formation and assignment of relationships between the surfaces of parts, regulated by the current system of standards, as well as the existing principles for organizing design and technological preparation, made it possible to identify a number of problems associated with the ambiguity, incorrectness and inefficiency of setting requirements for the relative position of surfaces on the drawings.
These problems are generated at the stage of creating drawings. And they consist in the arrangement of coordinating dimensions. The indicators of relative position include: 1) the distance between two surfaces; 2) the angular size or relative rotation of one surface relative to another.
In domestic mechanical engineering, it is traditionally customary to strictly separate the functions, tasks and organizational structures of designers and technologists. In this regard, there are controversial points due to the so-called "contradictions" of an organizational nature, when the performance indicators of design solutions in designing diverge from the characteristics of rational technology. In fact, when designing a part, it is very important to adhere to technological principles. The design process is closely connected and intertwined with the development of technology.
The stage at which the issues of ensuring the accuracy of the relative position of the surfaces are solved is the design process of the machining technology of the part. The processing method mainly determines the accuracy of the size of the surface being machined, its shape and roughness, while the accuracy of the size coordinating the surface - the accuracy of the surface location - depends primarily on the position that the part occupies on the machine - on the method of basing. Therefore, the choice of a set of part bases is directly related to the task of ensuring the specified accuracy of the relative position of the surfaces.
Let it be necessary to machine a hole in the part (fig. 1), the position of which is given by the coordinating dimensions A and B relative to the surfaces of the part's faces.
Since anybody in three-dimensional space has six degrees of freedom (three linear displacements along the coordinate axes and three rotations around these axes), then, based on the existing basing theory, the part must be deprived of these six degrees of freedom.
Part faces are flat surfaces with a maximum of three degrees of freedom. For such, prismatic, workpieces, basing is used on the installation, guide and support bases. The installation base is built on three reference points and fixes three degrees of freedom, the guide base is formed on two reference points and fixes two degrees of freedom, and the reference base uses one reference point [2].

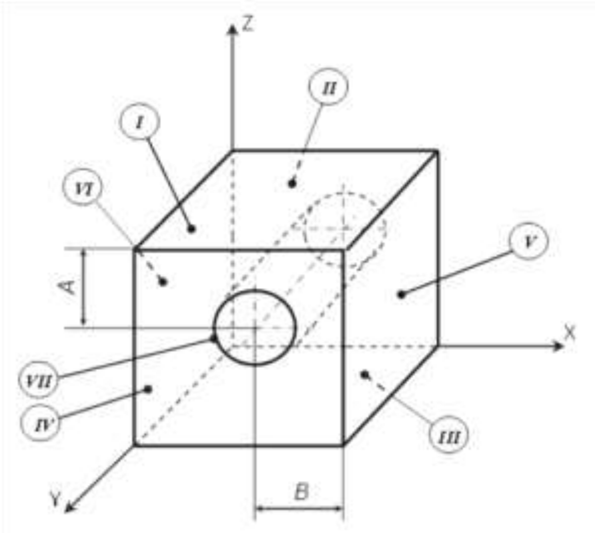

Fig. 1. Detail

Surface irregularity *VII* relative to the surface *IV* no more than 0,05 mm

Thus, for the workpiece shown in fig. 1, plane I can be chosen as the mounting base, plane *II* as the guide, plane *III* as the reference. However, this option is not the only one. Even in the considered set of bases, each of the planes can act as an installation, guide or support base. Then for the considered planes (*I*, *II* and *III*) at least six basing schemes can be formed. And if we take into account the option when each of the considered planes will provide deprivation of only two degrees of freedom, then a seventh basing scheme appears.

In addition, it is worth noting that other planes of the workpiece can act as a set of bases. Therefore, the resulting set of basing schemes, although finite, has a rather large power.

The choice of a specific basing scheme is the task of the technologist and is a problem associated with the ambiguity of the requirements of the drawing. To solve this problem, it is necessary to take into account the functional purpose of the part, the capabilities of the equipment available at the enterprise, and the processing technologies used.

As noted above, the choice of a set of bases and a base scheme significantly affects the relative position of the surfaces of the part. Dimensional chains are a tool for ensuring the accuracy of relative positioning [3]. It is the dimensional chain that makes it possible to mathematically represent and describe the relationship of dimensions between the surfaces of a part and optimize the requirements for the accuracy of geometric parameters.

However, the existing guidelines [4], containing the methodology for constructing and calculating dimensional chains, do not allow unambiguous and rational construction of dimensional chains and do not offer a mathematical apparatus by which complex dimensional chains could be formed.

Methods for setting the dimensions of elements that determine their relative position are regulated by GOST 2.307-2011. As an example illustrating the possibilities of setting dimensional chains and the consequences associated with this, a comb-type detail can be considered (fig. 2).

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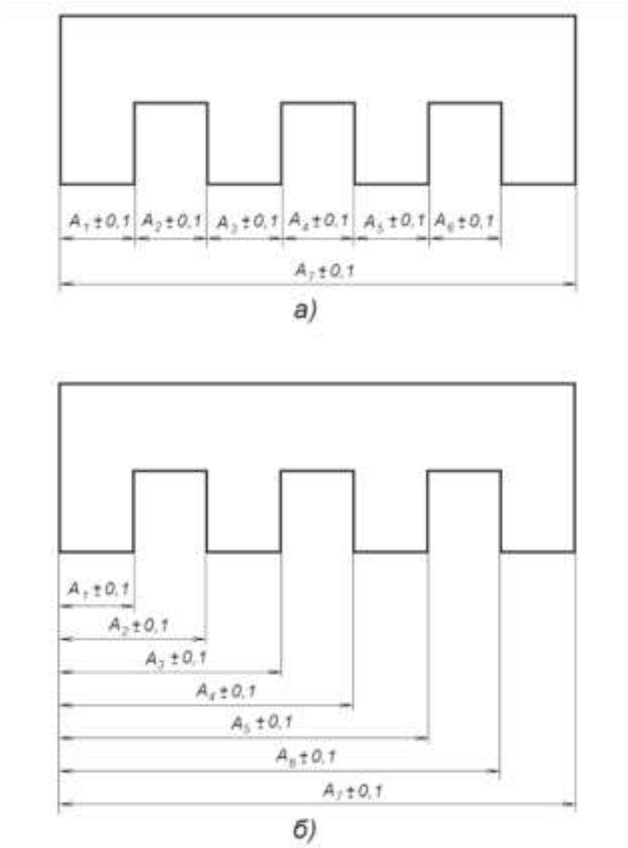

Fig.2. Methods for setting the dimensions of a comb-type part:
a) a chain; *b*) from the main base

The designer can put down the dimensions sequentially from one to the other, the so-called "chain" (fig. 2, *a*). In this case, the tolerance value of the last size (the closing link of the dimensional chain) in this case, calculated as the sum of the tolerances of the constituent links, will be ± 0.7 (the absolute value of the size error is 1.4 mm). With large numbers of teeth, for example, 10, 20, the accumulated error will be from 2.1 to 4.1 mm, which will actually lead to significant and unreasonable costs for fitting, and essentially to a marriage generated during design.

There is another way of sizing. With this method, the dimensions are affixed from the main base parallel to each other (fig. 2, *b*). The maximum error of any closing link with this method will be ± 0.2 mm, which is more than 3 times less. Despite all the obviousness of the situation, neither in the ESKD system, nor in other governing documents, the choice of one method or another is not regulated and is quite acceptable.

Based on the foregoing, we can conclude that all the problems associated with ensuring the accuracy of the relative position of the surfaces of the part during metalworking reach the level of design preparation for production. Therefore, design preparation should be closely related to technological preparation, paying special attention to the manufacturability of the product design. Registration of design documentation (drawings, 3D models) should contain a complete set of necessary and sufficient information for an unambiguous reconstruction of the real image of the part.

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