The layout method is an effective method for creating a product design

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Abstract. The advantages of creating a product design by the layout method are shown. An example of using the layout method when creating modular machines is given. It is noted that the effectiveness of using the layout method largely depends on the quality of the element base; the characteristics of the element base are given. A methodological approach to the construction of element bases is proposed, including the division of the element base into two parts: the base of the main elements and the base of the auxiliary elements.

When creating products, the following methods of a diverse nature are used [1, 2, 3].

The method of succession is the gradual development of a design by introducing into it new or additional parts, units, assemblies to replace obsolete or those which don’t meet modern requirements, in order to change the previous characteristics of the product. The method is based on improving the existing product design.

The standardization method is the creation of a structure based on the use of standard parts and units, elements with standard parameters. This allows to use already developed technical documentation.

The method of unification is the elimination of unnecessary diversity by reducing the list of permissible elements and solutions, bringing them to the same type, multiple use in the design of the same parts and units.

The basic unit method is the production of various products, united by the presence of the common, basic part. Typically, this element is the most complex part of future products. The development of the base part is carried out in such a way that, by attaching additional parts to it, it would be possible to create products with a changed appearance, the number of functions performed, and characteristics quite simply and quickly.

Modification method - alteration of a product in order to adapt it to new requirements, working conditions, technological process (method of manufacturing and assembly) without changing the most expensive and critical parts in it.

The inversion method is the creation of a new design based on changes in the functions, shapes or positions of parts of an existing product. For example, to replace the tension spring with a compression spring, to make the convex surface concave. The layout method is the design of the product structure by combining the elements that make up the element base.

Its application begins with establishing the type of the product with its layout diagram, and the elements corresponding to it. The layout of the product design is drawn up in the form of a preliminary
assembly drawing of the product design. After revising the project, the final technical documentation for the product and its specification is drawn up.

This method of creating a product has found wide application in mechanical engineering. Almost the design process of any product includes an element of its layout. In cases where the proportion of the assembly process dominates the entire product design, the product can be considered to be designed by the layout method.

Layout is a complex and responsible design task that takes a lot of time. One has to analyse several possible options and choose the best. In this case, the layout is a stage that largely determines the quality of the product.

The construction of products by the layout method allows you to significantly increase the efficiency of product creation by reducing the cost of product design, design time, costs of manufacturing the product and testing the design of the product on the first copy, contributes to the automation of the design process, facilitates the repair of products, and expands the unification and standardization of elements.

It should be noted another significant advantage of creating a product by the layout method, which is called reversibility. It allows, after the failure of the product, to reuse elements that have retained their quality.

The layout method is based on the element base, the quality of which largely determines the effectiveness of its application.

Modular machines [4, 5, 6] are an example of creating products by the layout method.

Modular machines are those which are assembled from unified and partially special units and parts by combining them into a single assembly [1, 2, 3].

The layout of modular machines is carried out by forming the structure of modular machines using normalized units (figure 1).

![Figure 1. Layout of a single column modular machine with rotary table. 1 - side frame, 2 - electrical cabinet, 3 – rack, 4 - power table, 5 - power headstock, 6 - spindle box, 7 - instrumental, adjustment, 8 - bush plate, 9 –clamping device clamping device, 10 - rotary table, 11 - medium bed.](image)

Such a design of modular machines implies the presence of the element base.

Elements of modular machines consist of four main groups of unified units: power units (power heads and tables), spindle units (power heads and spindle boxes), base units (bed, column, thrust squares), transport units (dividing tables).

Success in the creation of modular machines is determined by the presence of the listed elements in the base.

Thus, the creation of modular machines turns into their layout from normalized units. The technical documentation is known and is kept in the database.

When forming the element base of modular machines, several units of the same type (assemblies) of different sizes (called normalized or unified) are developed, which make it possible to design a machine that quite well corresponds to a given technological process of manufacturing a part.
Unified or normalized units of modular machines are developed before a particular machine is designed. These units can be used in machines of various designs.

Thus, the efficiency of building products by the layout method largely depends on the quality of the element base.

Taking into account the advantages of the layout method, it should be used whenever possible when creating all products. This requires the organization of the element base of products.

However, the unlimited variety of products for service purposes gives rise to an unlimited variety of product designs. It creates the problem of creating a single element base on the scale of mechanical engineering.

This is the reason why in future we will consider the problem of creating element bases at the enterprise level, when each enterprise forms its element base.

In this regard, an urgent task is to develop a methodological approach to the construction of element bases for products for various purposes.

The element base of products is a collection of units and parts required to create a product design. The element base is characterized by the range of elements, their quality, the level of element description, completeness and openness. The range of elements can be divided into two groups: the main elements directly involved into the performance of the product for its service purpose and auxiliary elements of general purpose, such as screws, nuts, bearings, pumps, and so on. It is the first group of elements that determines the difference between products for different purposes.

Another important characteristic of the element base is the quality of the elements, the indicators of which may be different depending on the purpose of the elements. At the same time, the quality element will be the element that corresponds to the modern achievements of science and technology. The completeness of the element base is characterized by the level of coverage of the range of product design elements. The completeness of the element base should cover, if possible, the entire range of structural elements of products for this purpose. Determining the completeness of the element base is also a difficult task, since there is inaccessibility of information about many elements.

Also, an important characteristic of the element base is the level of description of the designs of product elements. In some cases, the same elements can be presented in the form of sketches, and in another case - in the form of drawings with comments. The element base may include design options for the same elements.

The element base should be open, since its state changes over time due to obsolescence of elements that should be replaced with modern elements of a higher quality, as well as the introduction of elements of new structures. Therefore, should control over the state of the element base in order to introduce new elements on time.

Taking into account the abovementioned, we will consider the construction of element bases at enterprises.

The enterprise must organize two element bases: one containing the main elements and the other containing auxiliary elements.

The first element base may be different depending on the level of production of products. For example, the element base of vehicles at the level of the mechanical engineering sub-industry will include elements of aircrafts, ships, cars, motorcycles and other vehicles, and the element base of cars will include only elements that are part of the design of cars.

As the analysis of the elemental bases of various products shows, they mainly contain the main elements that directly ensure the performance of the products for their service purpose. For example, the element base of cars contains, first of all, bodies, cabins, chassis, engines, etc.

Element bases are formed according to the results of statistical studies of the frequency of use of the marked elements, which make it possible to establish the elements most often found in products and include them in the element base. Such formation of elemental bases significantly reduces their quality and efficiency of use.

In connection with the abovementioned, the following is proposed.

Firstly, all the elements of the product. should be included into both element bases.
Secondly, element bases should be formed before organizing the production. Thirdly, all elements of the first and second groups should be included into the element bases. Over time and as the design of the product develops, the composition of the element base should change by eliminating obsolete elements and including new elements. Another significant drawback of element bases is the absence of auxiliary elements of the product design. For each type of product, the corresponding auxiliary elements are typical. The lack of an element base of auxiliary elements significantly reduces the efficiency of the layout method, since the designer has to spend time looking for them in other sources of information, and in the absence of them, offer his solutions. So, the element base of any group of elements should contain a range of elements, as well as options for elements of the same name. Further, in the element base, different values of the characteristics of each element should be reflected, for example, dimensions, level of accuracy, and others. The construction of element bases should begin with the development of a classification system, including the classification of the names of the elements and the classification of each element. The presence of a classification of elements allows them to be encoded, which is necessary for creation an information retrieval system. When organizing element bases, difficulties arise with the construction of the classification of elements, due to a wide variety of their designs. In this regard, it is proposed to use the description of the product design in a modular representation [7, 8]. Then the functional technological module is taken as the main elements, and the functional serving modules, ensuring the functioning of the first modules, are taken as auxiliary elements. For example, a screw-cutting lathe performs its service purpose with three functional technological modules: a chuck, a tailstock and a cutting tool holder. Functional service modules include a gearbox, an electric motor, etc. So, the conclusions are as follows:

- Application of the layout method increases the efficiency of product creation by reducing the cost of designing and production.
- The effectiveness of using the layout method largely depends on the quality of the element base.
- The element base should consist of two parts: the base of basic elements and the base of auxiliary elements.
- The element base is characterized by the range of elements, their quality, completeness and openness.

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