GENERATIVE GEOMETRICAL DESCRIPTION OF PART THROUGH SET OF ITS BASES

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Abstract: *In the modern CAD systems the geometry is described by geometric features. The features can be considered as engineering primitives that are adapted to perform some engineering tasks. By addressing the sets of bases as geometric features, in this work an analysis of the advantages of that geometric description of parts is done. Sets of bases are represented as a connective element between conceptual and geometrical models. On an abstract level the proposed description allows a generation of different geometric configurations that meet the functionality specified in the conceptual stage of the design process. A description of parts on the geometrical level in sets of bases allows the creation of a more realistic CAD model of an assembly. The description of a part through its sets of bases is called generative, because it can generate multiple geometric implementations which satisfy the imposed functional requirements.*

Keywords: SETS OF BASES, GEOMETRICAL DESCRIPTION, INTEGRATED GEOMETRICAL MODEL, GEOMETRICAL FEATURES, CAD MODEL OF ASSEMBLY

1. Introduction

In the contemporary CAD systems geometry is described by geometric features. Features can be seen as engineering primitives that are adapted for the solution of any engineering problem. They can be used as building blocks, which what assemblies can be defined. In clear terms, the features are [3]:

– physical constituents of a part;
– allow geometry to be generated;
– have engineering meaning;
– have predictable properties.

The system must support at least the two main parts of the definition of the feature – geometry generation and engineering significance. The generation of the geometry can be formalized by using a generating set of parameters or geometrical elements and relationships between them. The engineering significance is difficult to formalize in a uniform way, because it includes the formalization of the functions of features and how they should be produced, what action should be taken in the presence of a feature in connection with any calculations, how features are held in different situations and etc. The engineering significance can be formalized in terms of generating attributes and properties.

By addressing sets of bases as geometrical features, this work analyzes the advantages of the geometrical description of a part through its sets of bases.

2. Sets of bases as geometrical features

Let's look at the extent to which the term "set of bases" [1] corresponds to those requirements of the features:

1. To be physically components of parts.

The set of bases, depending on the basing scheme, is a combination of the following base surfaces:

– adjusting base – takes 3 degrees of freedom;
– guiding base – takes 2 degrees of freedom;
– double guiding base – takes 4 degrees of freedom;
– supporting base – takes 1 degree of freedom;
– centring base – takes 2 degrees of freedom.

The implementation of these bases is done by real surfaces (explicit bases) or abstract elements (implicit bases), represented by the reference surfaces, axes and points belonging to the part. In other words, the first requirement is satisfied completely.

2. To allow generation of geometry.

The set of bases is by nature a prerequisite for generating the geometrical shape of the part in the following aspects:

– determines the mutual arrangement of the elements of the part's geometry;
– depending on the type of the base, the particular variant of its embodiment can be searched into a previously developed database of parameterized geometries.

3. To have engineering meaning.

Sets of bases as features are laden with engineering information relating to both the structure of the part and the structure of the assembly.

The introduced in the Theory of basing concept of "primary and auxiliary bases" allows identifying the topology of an assembly as a hierarchical structure. Such structural description carries the mutual arrangement of the parts which is necessary for solving engineering problems, analysing geometric accuracies (problems of dimensional analysis of assemblies) and performing tasks related to technology of assemblage (contriving schemes of assemblage).

4. To have predictable properties.

The properties of the sets of bases are discussed in the Theory of basing and limited to the following:

– by the properties "primary base" and "auxiliary base" the relation of "hierarchy" is realized (determined by the type of base – primary or auxiliary – of joining together parts) in the structure of the assembly;
– reconciliation of the primary and auxiliary bases realizes clearly the relation of "neighbourhood" (determined by the relation of one to other parts) between the parts and accuracy of their positioning.

3. Generative description of a part through its sets of bases

In Figure 1 it is shown the relationship between sets of bases of components of an assembly, and the stages of the design process:

– basing of a component depends on its function in the assembly – to ensure the proper functioning of the assembly basing of its components must be determined at the time of the transition from the functional scheme to the structure of the assembly;
– the structure of a product depends in the great extend from the basing of the components through relation primary bases – auxiliary bases;
– the embodiment design of parts has to secure an implementation of the chosen set of bases.

The description of a part through its sets of bases is called generative, because it can generate multiple geometrical realizations that satisfy the functional requirements. A variety of geometrical

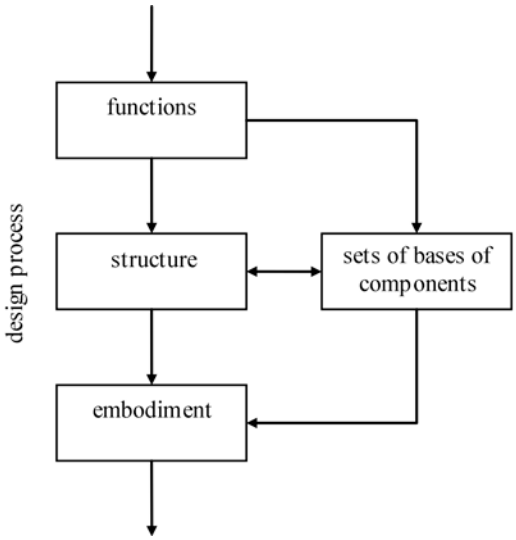

Figure 1 *The sets of bases in the design process*

implementations is dependent on the level of the description of sets of bases. With an abstract description of the sets of bases (via abstract geometry) the ability to generate a variety of geometrical forms is significantly larger in comparison with the particular description of the bases (such as the forehead, cylindrical surface, etc.).

Depending of the concrete design task the description of a part through its sets of bases can be observed as one of the several partial models of the part itself or as an addition to the existing model. For traditional geometric models of assemblies that are created during the design process, it is useful the information of sets of bases of parts to be included on the following levels:

– abstract level – structural schemes with a description of the sets of bases of parts (extended structural schemes);
– geometrical level – CAD models of parts and assemblies with preservation of the information about sets of bases of parts.

4. Application of the generative description of a part through sets of bases

In terms of CAD systems the description of a part by sets of bases offers advantages in the following areas:

– integration of conceptual and geometric models of a technical product;
– creation of a more realistic model of an assembly.

The use of means for automation of the design may be connected with problems when changes in logically linked models are made. The main reason for this is that the modern software tools typically automate only partial tasks. In practice this means the presence of many partial descriptions of the product, which correspond to different stages of the design process or of the various subtask [2].

The elimination of the need to convert the partial descriptions can be achieved by creating an integrated description. The possibility sets of bases to be considered from two perspectives – conceptual and geometrical – make them an adequate basis for the creation of an integrated geometrical model. Figure 2 shows the structure of an integrated geometric model produced by this principle.

From the viewpoint of the CAD system, a description of sets of bases allows to overcome certain limitations of a model of an assembly.

A creating a model of an assembly is illustrated in Figure 3. In Figure 3a there are imposed two constrains – mate of flat surfaces on both parts and mate of their cylindrical surfaces. The analysis of the removal of the degrees of freedom shows as follow:

– mate of the two flat surfaces takes 3 degrees of freedom;
– mate of the axes of the two cylinders takes 4 degrees of freedom.

Taking into account that the solid body in the space has 6 degrees of freedom (and there is 1 untaken degree of freedom), it is seen that the model is over constrained. In actual assembly of parts, however, there are taken exactly five degrees of freedom, which indicates the limits of the model of an assembly.

Similarly, if is looked at the assembly on the Figure 3b it is shown that in the CAD model the three flat surfaces are equivalent. In the real construction each of the three flat surfaces fulfils a different role and therefore takes 3, 2 or 1 degrees of freedom.

The addition of a description of the part through its sets of bases allows overcoming that restriction of the CAD model of an assembly. In Figure 3a the sets of bases can be double guiding and supporting bases (4-1) or adjusting and centring bases (3-2). For

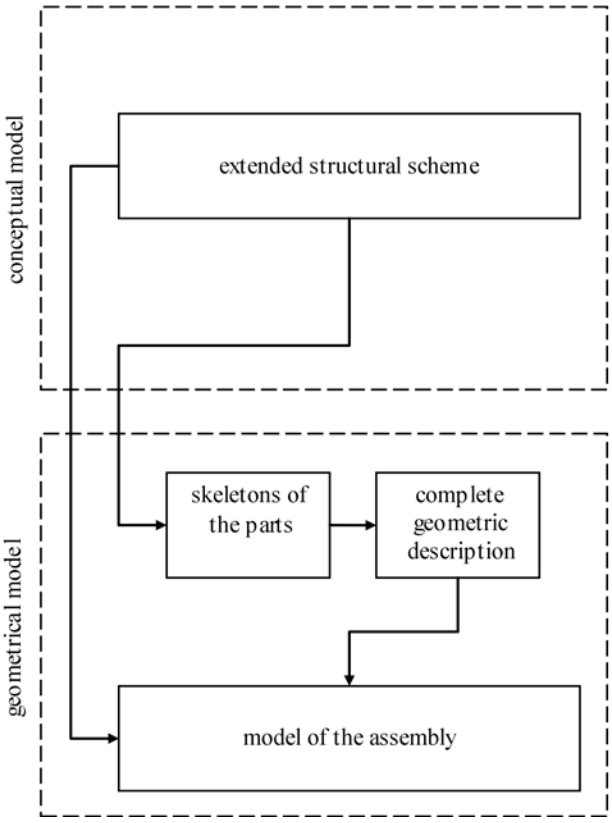

Figure 2 *Integrated geometrical model*

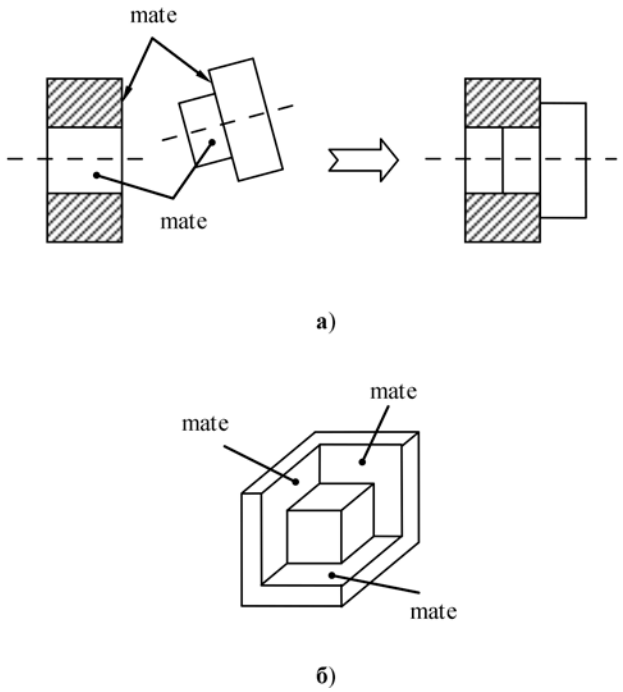

Figure 3 *Assembly constraints in a CAD model*

Figure 3b – accordingly adjusting, guiding and supporting bases (3-2-1).

5. Conclusion

Sets of bases characterize parts of an assembly and have been a proven from engineering practice tool for determination of the layout. Neighbourhood relations and hierarchy generated by the sets of bases uniquely determine the structure of an assembly. Their use offers several advantages, both at the conceptual design of the product, and at the time of its embodiment.

6. Literature

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