Automation of selection of technological bases as a basis for formalization of technological design

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Abstract. The article is devoted to solving the automated selection of technological base. There is an attempt to present the mathematical solving the problem as a problem of depriving the item of six degrees of freedom and defining the surfaces set, which can be processed at one installation. The rules of base selection from the point of view of engineering technology are propounded to introduce as limitations at the later stages of solving the problem. The article makes a conclusion about the possibility of the further complication of the algorithm and raising the quality of solving the problem.

1. Introduction

The technological preparation of production is impossible without using informational technologies. A lot of automation systems were created for automation of technological preparation of production, but the automation level of technological solutions is not high enough.

The problem of raising the automation level of technological designing is connected with the solution of two principle problems: retain information about the part into the computer – aided design and the formalization of the technological design process.

The solution of the first problem is possible with using the group of international standards of changing information about an object, named STEP [1]. We’ll say about using this method later.

The solution of the second problem may be more difficult. It is connected with the lowest level of formalization of technological solutions in mechanical engineering [2].

First of all it is connected with the most difficult stage of the development of technological process – forming a part processing route.

Perhaps, one of the most difficult problems of the development of technological process is the base selection and finding the surfaces treated with a single installation. These problems are connected with each other, and the formalization of the solution of the problem of the base selection will make it easy to solve the problem of automation of forming a part processing route.

During the mechanical processing a part, as a rule, is deprived six degrees of freedom. It makes it possible formally to imagine the problem of the choice of technological bases set as the problem of a search of a surface set, depriving the item of six degrees of freedom. And existing in engineering technology rules of base selection may be introduced at the later stages as restrictions.

2. Mathematical formulation of the problem

As a rule, the part must be deprived of six degrees of freedom. In spite of the difficulty of the problem of base selection for processing parts the number of variants of types of technological bases sets is not
so great. The problems of base selection of complicated irregular form details are not considered at this stage. The special adjustment devices such as lodgement are used for them. During processing typical body parts and bodies of rotation both in the first and in the second group the next variants of base surfaces combinations are possible. For basic parts it is a coordinate angle, which is realized by three planes, a plane and two holes and a plane, one large hole and a surface. External cylindrical surfaces, placed in the considerable distance from each other, may be used shafts a double guide base side by side with an axis.

The majority of CAD systems build a model of the part in the right Cartesian coordinate system. Let us see, how the bases are connected with coordinate planes.

The installation base for a body part is more often the plane coinciding or parallel to the coordinate plane XOY (it is not the obligatory condition). It deprives the part of possibility to move along the axis Z and the turnings around the axes X and Y. To deprive the part of the rest movements and turnings the planes being a guide and support base, must be perpendicular to the installation base and perpendicular to each other (it gives the name of the coordinate angle).

The hole in the body part can work as a support base or a double support base. The axes of the holes must be perpendicular to the plane being an installation base.

The basing of rotating bodies is connected with the ratio of the overall dimensions of the part. If the length of a cylindrical surface more than its diameter, then the cylindrical surface or its axis works as a double guide base, and the flat end surface works as a support base.

Therefore we need the information about the disposition of the part surfaces in the given coordinate system and overall dimensions of the surfaces for understanding the formalization of the process. This information can be received by different methods, for example, using the STEP standard exchange file[1]. Coefficients of the equation of the normal to plane are a part of the description of the plane in this standard. They may be used in the canonical setting of the plane. The canonical setting of the plane is expressed by equation.

$$Ax+By+Cz+D=0$$

In the planes, paralleled to coordinate planes only one of the coefficient of the variables x, y, and z is equal 1, all the rest are equal 0 (fig. 1).

This one will show along which coordinate axis the given plane will deprive of the possibility of removing. In accordance with it, the names of variables the coefficients of which are equal 0, will the axes around which the surface will deprive of possible turnings.

In the description of cylindrical and conical surfaces in a step standard exchange file a unity coefficient in setting the orientation of the normal vector corresponds to the axis of rotating the surface. In this case just in this direction the rotation will not be limited, but in two other coordinate directions both linear and angular movements are limited.

So the matrix of degrees of deprivation of freedom can be received from the matrix setting the surface orientation (fig.2). The degrees of deprivation of freedom were defined on a maximum that is the plane can deprive of three degrees of freedom, and the cylindrical surface – of four.

The receipt of the given matrix is the first step of the algorithm of solving the problem.

At the second stage of the work of the algorithm of defining all base sets it is necessary to get surface sets for which the vector of deprived degrees of freedom contains all “one”. The search is done by element – to – element addition of lines (but no more than 3). The numbers of these lines form all possible base sets.

During the basing with using cylindrical external and internal surfaces there are several situations. In order to have a better quality the initial information we must set a type of the detail: a body part or a body of rotation.
Figure 1. (a) an example of a part; (b) orientation of a surfaces

Figure 2. The receipt of the matrix of degrees of deprivation of freedom

For body parts internal cylindrical surfaces may be in a standard set of bases “a plane and two holes”. In this case the axes of rotation are perpendicular to the plane. In the matrix of degrees of freedom these holes have the same six-dimensional vectors. During forming the set the linear relationships were chosen from the first hole, and the angular relationship – from the second hole.

In the construction of parts of box shape may be found columns or bosses which in common may work as an installation base. For the exposure of such surface sets it is necessary to make a comparison of not more than three lines by coordinate Z and the size by height Zo.

3. Formation of possible sets of bases
It is necessary to choose only possible base sets. The first selection criterion is repeatability of the set for several surfaces.

Then one more limit is imposed on the received list of the base sets. This limit is connected with the matrix of dimensional relations. Given matrix is a square matrix, in which at the crossing of lines and columns, describing the surfaces, connected by size, units are put.

Besides the size between the surfaces it is often necessary to hold the disposition of the surfaces, for example, the deviation from parallelism or perpendicularity. Such demands may have a higher priority and be marked by “two” in the matrix of dimensional relations.

The lines and columns, containing a more units are selected from the matrix.
If the matrix contains “two”, then the columns and lines, connecting “two”, are chosen from it. Then from a selected before number of the base sets those sets are chosen which contain the surfaces, chosen from matrix of dimensional relations. The definition of the name of the base surfaces, used in the set is done at the last stage in accordance with the degrees of deprivation of freedom.

Any cylindrical part has two planes of symmetry, which form the axis when they cross. This feature makes it possible to use the axis as a base in basing cylindrical part.

As the initial data the number, the type of surface, the diameter, the length and the surface orientation are used.

Then the length of the whole part is defined and the average size of the diameter. According to the length to diameter ratio the axis will work as double support base or a double guide base. Flat end surface will be accordingly an installation base or a support base.

4. Conclusions

The propounded and realized algorithm of solving the automated selection of technological bases makes it possible to form a lot of variants of the part basing on the principles of mathematical solving the problem. The addition of technological rules of base selection at the following stages makes it possible to reduce the number of variants, received at the first stage, to the acceptable level. Automated defining the kinds of bases according to the degrees of deprivation of freedom is made in the obtained set of technological bases.

The suggested algorithm of solving of the problem of base selection is the first version of the solution and will be in following modified in the direction of increasing the number of restrictions imposed on the possible base set.

References

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[2] Mitin E V, Sul’din S P and Okunev D V 2018 Formalization of Automated Base Selection in the Design of Machining Processes, Russian Engineering Research 38(11) 886-888