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Dimensional technological chains construction and calculation

Using basic propositions of known scientific schools the program complex is created. In sight it can be integrated with CAD/CAM and used in production.

1. Dimensional calculations in machining

During designing of technological processes (TP) of machining the calculations of technological (operational) dimensions take important place. The subsequent carrying-out of these dimensions during TP should result in reaching the accuracy of a part prescribed by the drawing. Usually there are some variants of the workpiece machining route, and consequently, the variants of dimensional structure of TP connected to them. Solution by the technologist of the task of choosing the best in practice variant from the sequence of alternate variants is considerably complicated by the influence of dimensions accuracy of prior TP operations on accuracy of technological dimensions of the subsequent operations. For a real part, as is known, it is rather seldom possible to fulfill all design dimensions as they are filled in on the drawing, i.e. direct from measuring base. The designer dimension much more often turns out indirectly through a number of the interconnected intermediate technological dimensions, maintained from other bases on different reasons [1]. At the same time the real accuracy of designer dimensions will depend on accuracy of the several interconnected technological dimensions.

To simulate interconnection of technological dimensions at a design stage, and then to take into account the influence of accuracy of their dimensions on accuracy of designer dimensions is possible by composition and solution of specific technological dimensional chains [2]. Multiple composition of structural dimensional scheme of TP (graph) and revealing with its help closed outlines of dimensional chains with their qualitative assessment and quantitative calculation of balance of tolerances make essence of dimensional analysis of TP.

The most effective technique of the dimensional analysis is based on simulation of dimensional changes of workpiece by means of graph structures.

2. Source data preparation

Let's consider a content of the technologist's operation at TP dimensional analysis of the part - "Finger". Figure 1.2 illustrates part as drawing and 3D model.

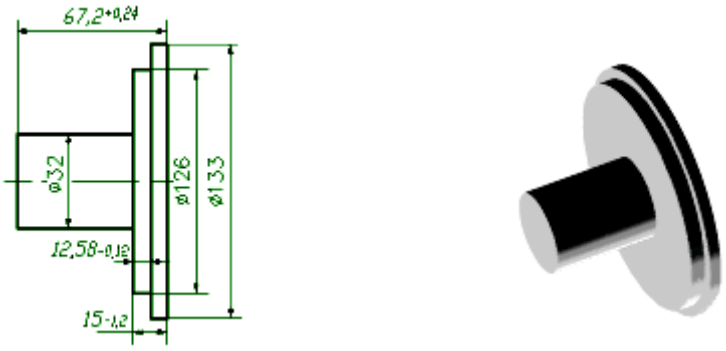

Figure 1

At first on the basis of the part's drawing and idea about the future structure of TP of its manufacturing, operational sketches of one or several, competing variants of manufacturing of a part are as usual created (figure 2).

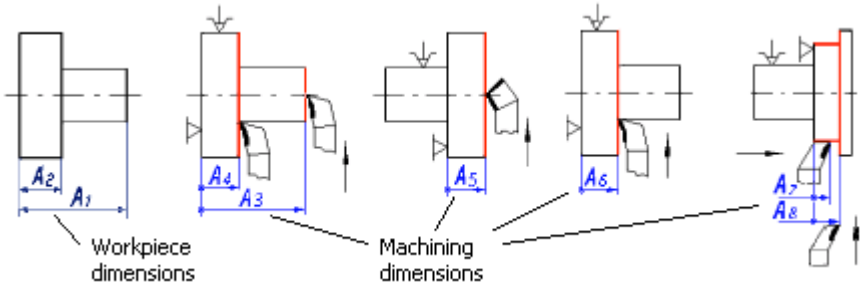

Figure 2

Unknown initial dimensions of workpiece are marked by double-side arrows, and the dimensions nascent at machining, - by one-sided arrows outgoing from adjusting or technological base. All technological

dimensions are designated by the character "A" with sequentially increasing index. After association of operational sketches turns out the so-called dimensional scheme (figure 3).

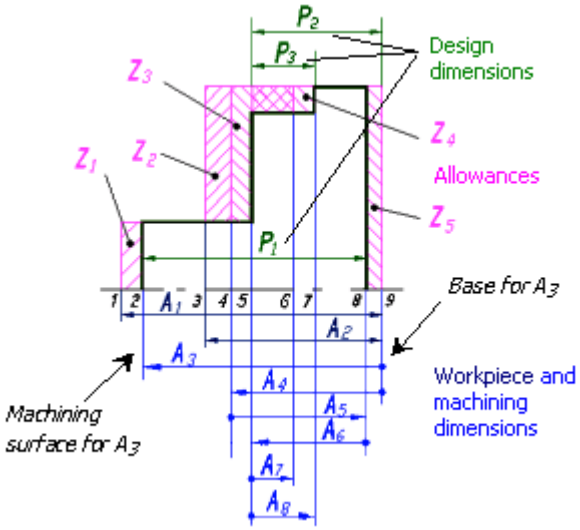

Figure 3

Design (drawing) dimensions Pi are specified above a part on this scheme, with sequentially increasing index. The allowances designated by Zi are numbered from left to right. All surfaces of the workpiece and the part also should be numbered from left to right.

Vertical lines are carried out through indexed surfaces. Between these lines dimensions of the workpiece designated by A i and the machining dimensions received as a result of execution of each technological change (operation) are put.

We shall remark, that workpiece dimensions are designated by double-side arrows, and workpiece and machining dimensions are represented on the scheme by a vector which is directed from a base surface to manufacturing (obtained) on the given change. It is necessary to underline, that only position of allowances and technological dimensions between the intermediate surfaces received during processing are indicated on the dimensional scheme. Values of dimensions will be calculated subsequently.

There should be represented so much chains on the dimensional scheme, how many there are design dimensions and allowances in the sum on the scheme, as each dimensional chain has only one closing branch (a design dimension or an allowance).

For the preliminary, qualitative analysis of TP variant it is possible to manually construct graph dimensional changes of the workpiece. And with its help to reveal equations of dimensional chains, and then to analyze them (Figure 4).

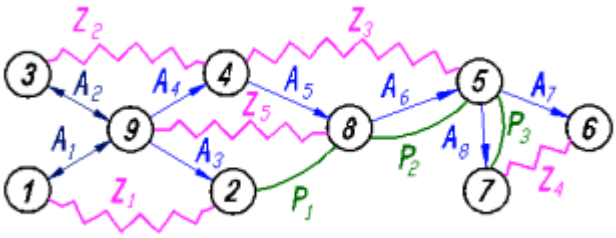

Figure 4

The process of revealing of technological dimensional chains can be considerably facilitated if on dimensional scheme construct structural model, using geometrical representations of graph theory. The part during its manufacturing can be considered as the geometrical structure consisting of set of surfaces - the tops designated on the graph by circles, and edges - sizes between tops which on the graph are represented by the segments of various sort connecting circles. There is a rule, according to which structure of the graph and consequently, the dimensional scheme of variant TP are constructed truly if the sum of design dimensions and allowances is equal to the sum of technological dimensions and dimensions of the workpiece.

With the help of the graph it is easy to visually search outlines of dimensional chains and to construct the equations (Figure 5).

By quantity of dimensions making each chain it is possible to estimate expediency of variant TP qualitatively. So, for example, at number of component branches for a chain with a closing branch - design dimension more than 2, support of accuracy of this dimension, will be probably problematic.

For complex parts with a plenty of dimensions, manually construction of the graph with the purpose of qualitative analysis of TP is embarrassed by numerous intersections of the branches. KON7 automizes revealing the interconnected outlines of chains, and - after check of their rationality and admissibility - solves the equations, outgoing from the given accuracy of designer dimensions.

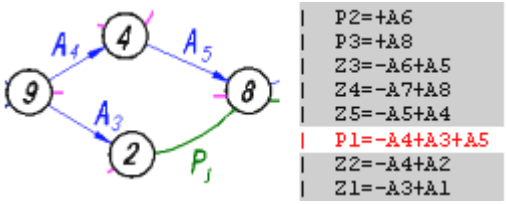

Figure 5

3. Program KON7

Being a variety of the CAPP-system, program KON7 is intended for the dialogue preparation of source data and the subsequent analysis of the TP dimensional structure.

The program automatically retrieves technological dimensional chains on the basis of the entered information about the TP structure and design dimensions accuracy of the part, it calculates nominals and deviations of tolerance of technological dimensions which should be sustained at manufacturing for reaching accuracy of design dimensions. In case of inadequacy of the offered variant, from the point of view of reaching accuracy of design dimensions of the drawing, the program outputs messages on each dimensional chain which specify a technological dimension with insufficient accuracy.

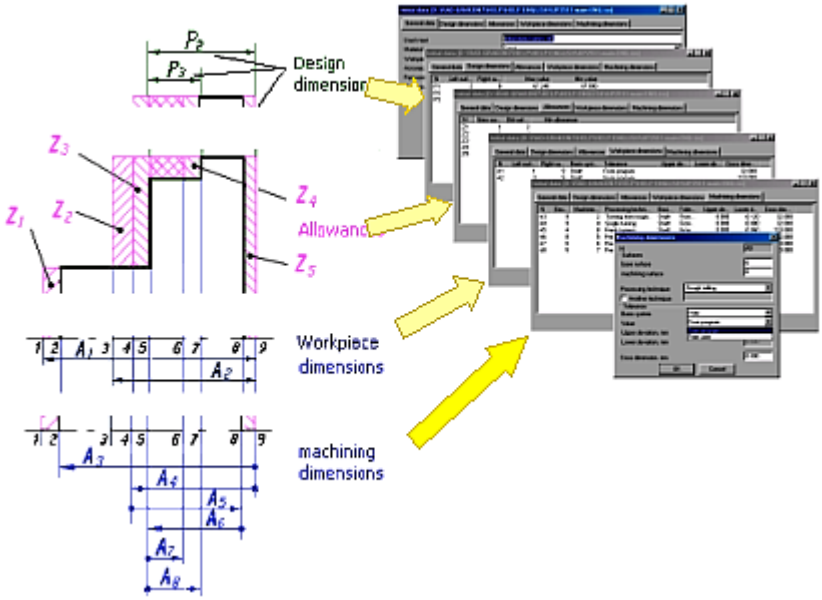

Figure 6

Thus, at usage of KON7 which function under the Windows 9x, it become possible to connect the preparation of the information, a rating of result and operating change of the data in the uniform complex for refining calculations of several variants of dimensional structure of TP. The calculated values of technological dimensions are put down in appropriate lines of an work instructions.

KON7 perform calculation on a method of max-min and has the following characteristic features:

- the task for one or several technological dimensions of "user's tolerances", taking into account real accuracy of the equipment - at discretion of the technologist, around of the normative database of the program;
- input of a guaranteed minimum allowance on manufacturing of one or several surfaces in case of impossibility of implementation of the underestimated, designed values of allowances on industrial conditions of workpiece obtaining;
- simulation of workpiece dimensional changes at manufacturing with quantity of technological dimensions not less than 300;
- adaptation of the normative database on tolerances of machining and workpiece obtaining methods, and also of rectangular components of processing allowances;
- customization of a degree of completeness of output results of designing on the screen and on printing;
- intelligent diagnostics of input data at input stage.

It is important to underline, that KON7 does not substitute the technologist, but only allows him to quickly analyze the accepted technological solutions of structure of the technological process, selected basing schemes, methods and accuracy of manufacturing from the point of view of main criterion - supports of designer dimensions accuracy.

4. Source data input

Source data input consists of General data, Design dimensions, Allowances, Workpiece and Machining dimensions (Figure 6).

Machining dimensions. They are entered in a sequence of machining of the workpiece: from rough machining - to finishing. The base surface - technological or adjusting base from which the dimension is maintained. The machined surface - a surface received as a result of deleting of an allowance or a lap by a selected processing technique.

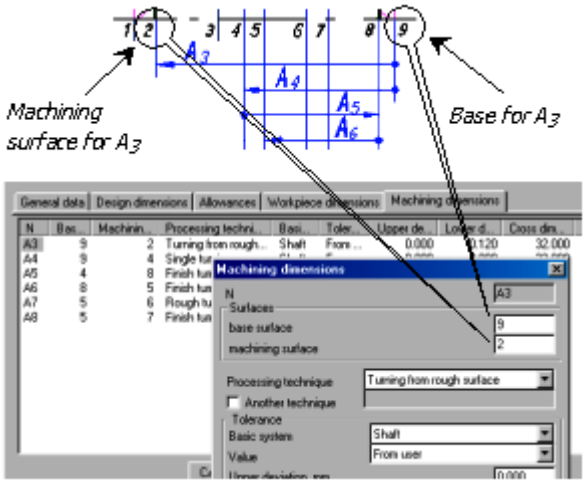

Figure 7

The tolerance on the dimension A will be calculated by the system, and then compared with the tolerance of the given method and character of processing. Planned layout of tolerance concerning a nominal of a size subject to calculation is underlined by the user in a field "Basic system".

The user can deselect tolerance choice from the database of the system and set its own value in fields of upper and lower deviations of a dimension. For this purpose a contents of a field "Value" should be preliminarily changed.

Automated construction and calculation of machining dimensions
KON7 (C) Kalachev O.N., 2000 (v.116_120 Dl zz GPA HA) Okalachev@mail.ru

User's text Initial data Ivanov #1

Table 1

Initial data (check entry accuracy!)
Workpiece characteristic:
Material..... Steel
Obtaining method..... Press form. com accuracy
Accuracy class..... ---
Guide overall dimension, mm 133.000

Closure branchs P-design dim., Z-allowances				Component branchs - A: workpiece dim.<---> & machining dim.0-->					C r o	Tolerance deviation <from user>, mm	
Bran chs	Surface |P: l-r |Z: n-o	Limiting values max	min	Bran chs	Surface <---> |base-->	Processing technique	Bas-ic	s syst	s dim.	upper	lower
P1	2 8	67.240	67.000	A1	1 9	Press form. com accuracy	shft	32		0.000	0.000
P2	5 8	15.000	14.880	A2	3 9	Press form. com accuracy	shft	133		0.000	0.000
P3	5 7	12.580	12.460	A3	9 2	Turning fr. rough surf.	shft	32		0.000	-0.120
Z1	1 2	0.000	0.000	A4	9 4	Turning single	shft	32		0.000	-0.080
Z2	3 4	0.000	0.000	A5	4 8	Turning finish	shft	133		0.000	-0.060
Z3	4 5	0.000	0.000	A6	8 5	Turning finish	shft	32		0.000	-0.120
Z4	6 7	0.000	0.000	A7	5 6	Turning rough	hole	133		0.000	0.000
Z5	9 8	0.000	0.000	A8	5 7	Turning finish	hole	133		0.000	0.000

Table 2

The results of denominate dimension chain's equation and consecution of its solution

Solution #	Unknown branch	Equations in character form
1	A6	P2=+A6
2	A8	P3=+A8
3	A5	Z3=-A6+A5
4	A7	Z4=-A7+A8
5	A4	Z5=-A5+A4
6	A3	P1=-A4+A3+A5
7	A2	Z2=-A4+A2
8	A1	Z1=-A3+A1

The user can cancel the allowance definition by designed way and set its own value. For cancellation of allowance's calculation it is necessary to mark choice and to enter numerical value of a minimum allowance into field Zmin.

The set of diagnostic procedures at various stages of source data input is stipulated in the program also during calculation. For example, in a figure is shown the response of the system to attempt to enter logically incorrect limit of a branch in a tab "Machining dimensions".

5. The contents of the results

After correct data set input by the dimensional scheme of variant TP in KON7 the button "Calculation" becomes accessible.

The system automatically reveals the equations of the dimensional chains, which closing branches are design dimensions P and allowances on machining Z. The generated equations are output as table 2 in which increasing branches are marked by symbol "+", and reducing - by symbol "-".

Apparently from table 2, the system defines a sequence of solution of dimensional chains and an unknown branch concerning which each chain is solved.

The results of calculation of nominals and maximum deviations of technological dimensions are shown in table 3.

Table 3

The results of dimension chains calculation with KON7 (C) Kalachev O.N., 2000 t. (0852) 475419

Closure branchs P-design dim., Z-allowance					Component branchs - A: workpiece dimensions <-->, machining dimensions 0--> kon7-116-120 D1 zz GRA-HA--						
Branch's index	Surface new	Surface old	Limiting values max	Limiting values min	Branch's index	Surface <--> base-->	Processing technique	Nominal	Deviations upper	Deviations lower
P1	2	8	67.240	67.000	A1	1 9	Press form. com accuracy	70.180	1.500	-1.000
P2	5	8	15.000	14.880	A2	3 9	Press form. com accuracy	17.810	1.200	-0.800
P3	5	7	12.580	12.460	A3	9 2	Turning fr. rough surf.	67.810	0.000	-0.100
Z1	2	1	3.970	1.370	A4	9 4	Turning single	15.940	0.000	-0.080
Z2	4	3	3.150	1.070	A5	4 8	Turning finish	15.290	0.000	-0.060
Z3	5	4	0.410	0.230	A6	8 5	Turning finish	15.000	0.000	-0.120
Z4	7	6	0.633	0.270	A7	5 6	Turning rough	11.910	0.280	0.000
Z5	8	9	0.710	0.570	A8	5 7	Turning finish	12.460	0.084	0.000

Besides, the intermediate information on each dimensional chain allows to estimate a degree of correspondence of design accuracy of a technological dimension and the given accuracy of machining. Analyzing this information it is easy to reveal the contribution of each branch into required accuracy of a design dimension.

The preferable variant is the variant in which in chains with closing branches "design dimension" - one making branch (the principle of "unity of bases" is maintained), and in chains with closing parts "allowance" - two making branches.

The quantitatively conclusion is done on the basis of table 3 of calculation results with values of the calculated technological dimensions A. If calculation interrupts before output of table 3, it is necessary to turn to the intermediate information of the last calculated chain. Thus the system informs that the given accuracy of designer dimension P can not be provided because of insufficient accuracy of a selected method of manufacturing. In this case, being oriented on the output accuracy of each technological dimension, it is necessary

a) to change the accuracy of a dimension obtaining method (for this purpose, probably, it is necessary to enter additional manufacturing and, accordingly, an additional technological dimension);

b) to change the scheme of basing, achieving decreases of the sum of tolerances of technological dimensions, according to a principle of "the shortest path".

For the registration of real accuracy of the equipment in KON7 system there is a possibility of detour of choice of their normative tables of the system. Cardinal resource of the registration of really maintained tolerance on manufacturing is adapting of normative base of the system which is possible

a) adjustment of the external file of the normative information without involvement of the developer;

b) modification in base of the system directly in a body of the program with involvement of the developer.

Thus, using system KON7, the technologist models part processing as dimensional structure and in real-time mode receives the conclusion about expediency of process variant from the point of view of obtaining required accuracy of the design dimensions of a part.

References

1. Laura Wakeford. How Your Design Can Affect The Cost, Quality And Time Required To Manufacture Parts. MCADVision Magazine - July 2001 - Part1.

2. Nicks J.E. Basic programming solutions for manufacturing. Society of Manufacturing Engineers Marketing Services Department. - 1982.