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# MODELLING
# IN AUTOCAD 2002 ENVIRONMENT OF DIMENSIONAL CHANGES OF PREFORM

One of the primary goals of a machine-building technologist is to design the process of machining. Thus it means, that developed technological process (TP) should provide parts manufacturing under production conditions with those parameters of accuracy of dimensions $A_i$, which are given by a designer (Fig.1).
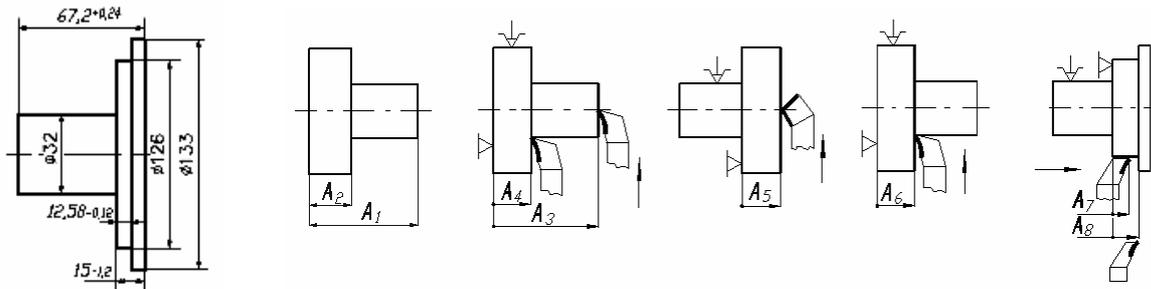


Fig.1

To realise this is rather difficult, as there exists a set of route variants of processing one and same part. Besides, the accuracy of the concrete dimension influences the accuracy of other technological dimensions; this association is not obvious, but can be established only by means of the detection of specific technological dimensional chains contours [1].

The system **GRAKON7** is launched in AutoCAD 2002 environment and provides automated construction of the dimensional scheme of variant TP on the designer's drawing, and then in an automatic mode - equations of technological dimensional chain and determines nominal values of all technological dimensions and tolerances on them.
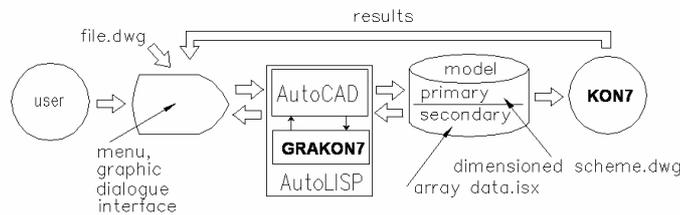


Fig.2

Source information is a file to models (the file of the drawing) of the detail. The system **GRAKON7** by means of graphic dialogue with user (Fig.2) leads creation to primary model directly on screen from deskside of the detail in order to inverse processing (see Fig.1), i.e. will reconstruct the surfaces of the stocking up in given coordinate direction,
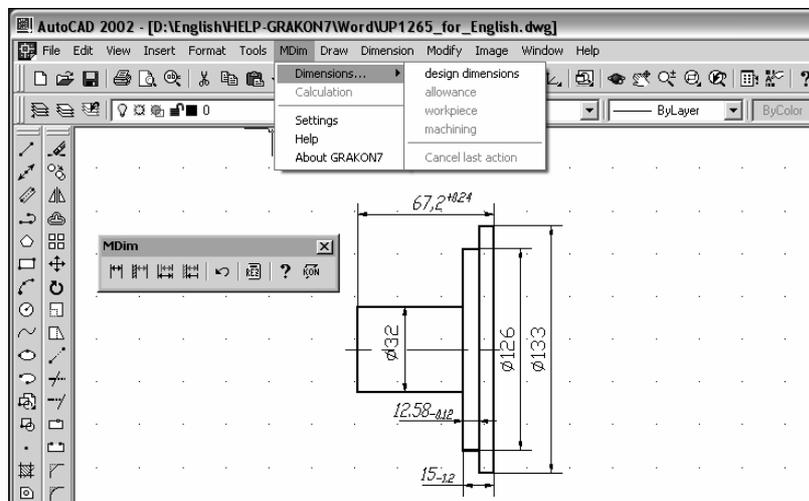


Fig.3

building on allowances one for others, indicating position of the sizes of the stocking up and technological sizes of the processing $A_{i.}$. The system "loads" sizes of the stocking up and technological sizes introduced by means of dialogue menu by technological information on method and nature of the processing, supposed location tolerance. On base specified by user-technologist of the position of the technological sizes and method of their reception system **GRAKON7** forms the secondary model of the dimensioned change, which is arranged in the manner of list of the structure, converted then in matrix of the raw dates for the following searching for of the composition and decisions of the dimensioned chains in module **KON7**. The facility of the analysis to models of the detail, organizations of the dialogue and creation to secondary model in AutoCAD 2002 serves the language AutoLISP.
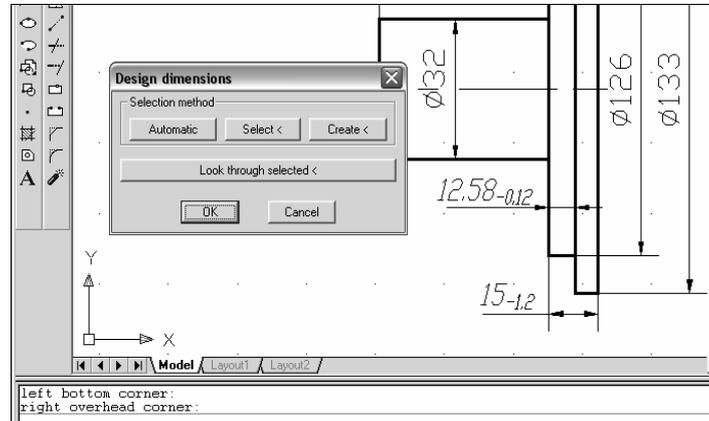


Fig.4

Using of **GRAKON7** is especially efficient in the conditions when during TP there is an often change of bases and the well-known principle of the "unity of bases" is not observed, i.e. there is an error of basing which is difficult to identify and take into account without constructing and solving technological dimensional chains.

Using the program **GRAKON7** allows also to identify "bottlenecks" of operations and jumps, low dimensional accuracy of which is the reason of insufficient accuracy of the final part's dimensions.

Starting to work with the system, technologist loads in AutoCAD 2002 part drawing performed by designer, and then presses screen button **MDim** (Fig.3). Using item "***Dimensions***", designer gets access to the specialized interface to construct dimensional scheme of variant of technological process directly on part drawing on the screen. According to items of the cascade menu the construction of the dimensional scheme is performed in four stages.

*1. Design dimensions.* By pressing screen button "***Automatic***" (Fig.4) all surfaces combined by designer's dimensions horizontally orientated are automatically identified. After confirmation by button ***OK*** all chosen surfaces are joined by dimensional lines, numerical values of dimensions appear above them (Fig.5).
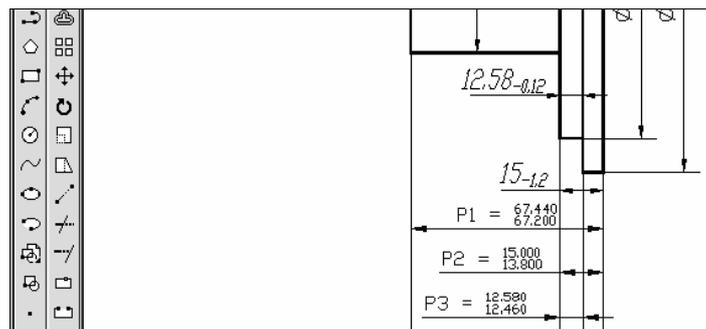


Fig.5

As a result the dimensional structure of a part, which displays dimensional associations between surfaces that should be obtained after machining, is selected. If it is necessary, the system allows to add the drawing with missing dimension or to set the dimension instead of incorrectly entered and to specify its limiting values by pressing the button "***Create***". User is offered to highlight with cursor one, and then another surface (lines) of the drawing, which should be connected by the designer's dimension. Button "***Select***" allows to select the separate dimension, for example for correcting its limiting values.

The system automatically identifies the tolerance of dimension, correctly entered by means AutoCAD 2002 while creating the drawing, replacing it with its limiting values of the dimension (see Fig.5). In case of incorrect tolerance on the drawing the system requests user to specify nominal value and deviations manually . The button "***Look through selected***" (see Fig.4) allows to launch successive viewing of selected dimensions and in case of need to exclude

the dimension from the further analysis of the structure of the part. In the end the system offers user to proceed to allowances input.

*2. Allowances.* The task of the given stage is indication of allowances' position, discarded during processing. The technologist attaches the necessary number of allowances for each surface by means of the system. Button "***Add allowance***" in the dialogue menu (Fig.6) is used for this purpose. After pressing this button it is possible to create one allowance: in AutoCAD 2002 prompt line there appears the request about the choice of the surface to which it is necessary to attach the allowance. The user puts cursor on the line of the surface and presses the button of "mouse". After that request about where the allowance should be placed appears. The user moves the cursor rightward or leftward from the specified surface and presses the button of "mouse" - rectangular is attached to a surface and a line of newly formed workpiece surface appears. If the given surface demands both finishing, and roughing, the previous allowances are formed similary. This process is repeated until the desirable number of allowances is specified for all surfaces of the part drawing. The dimensional scheme on the screen is dynamically reconstructed while additing the allowances. Wrongly specified allowance can be removed, using the button "***Remove allowance***".
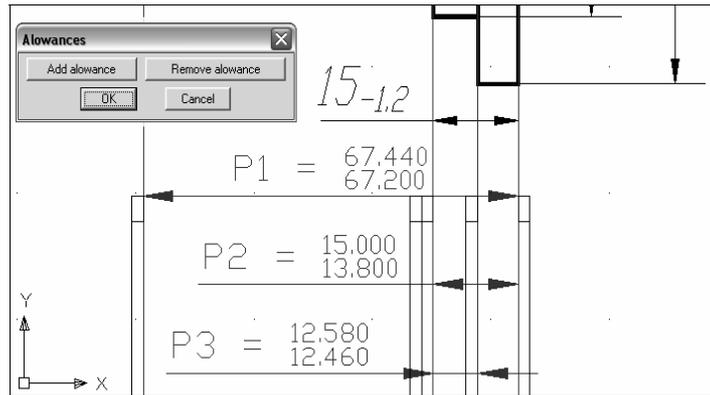


Fig.6

Pressing button ***OK*** completes the stage - as a result the sketch of the part is converted to the sketch of workpiece. System informs about the quantity of the entered allowances and offers to proceed to the next stage for the indication of the workpiece dimension position, with which it comes in machining process.

*3. Workpiece.* The stage is initiated by choosing item "***Workpiece***" (see Fig.2). In order to add one dimension of workpiece, it is necessary to press the button "***Add dimension***" in appeared dialogue window. In reply to the system request it is necessary to specify with cursor the first and the second lines consecutively, which models the appropriate surfaces of workpiece that have appeared after the input of allowances. After the definition of the dimension location it is necessary to mark with radio-button in the menu (Fig.7) intended position of it's tolerance relatively to face value, and also to enter boundary dimensions in cross-section featuring the least rigidity of workpiece. Then the same actions are repeated for the next dimension.
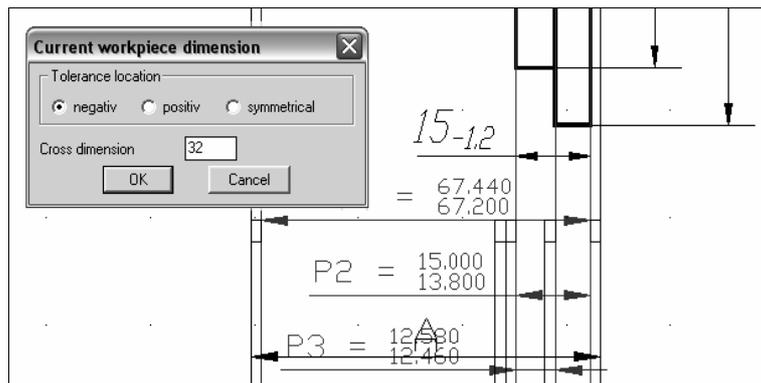


Fig.7

As a result of the stage at the bottom part of the formed dimensional scheme all dimensions of workpiece will be represented by bilateral arrows and designated by the letter "**A**" with consecutively growing index. After pressing the button ***OK*** the system informs the user about the number of the entered dimensions workpiece and offers to proceed to a stage of technological dimensions of machining indication.

*4. Dimensions of machining.* Here user specifies technological bases, adds positions and chooses a method of obtaining technological dimensions maintained at workpiece machining. The technologist is offered to press (Fig.8) the button "***Add dimension***", and then to specify the base surface from which the size is maintained, and then - processed surface, obtained after removal of the appropriate allowance. These actions can be performed with cursor directly

within the limits of workpiece-part contour. At the technological dimension (unlike the workpiece dimension) the base surface is automatically marked by a point, and the arrow goes to the processed surface.
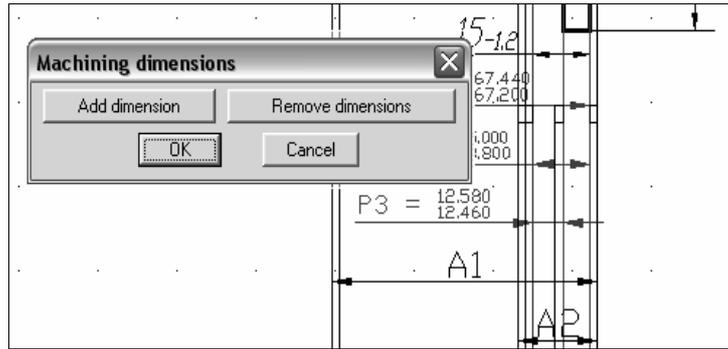


Fig.8

After the input of the borders of the current dimension, the system requests a method and character of surface processing (Fig.9), an arrangement of the dimension's tolerance zone and overall dimension in cross section of the plane of processing, featuring the rigidity of adjustment. Pressing **OK** button returns the first dialogue window of the stage on display. The considered sequence of data input is repeated then for the next dimension.
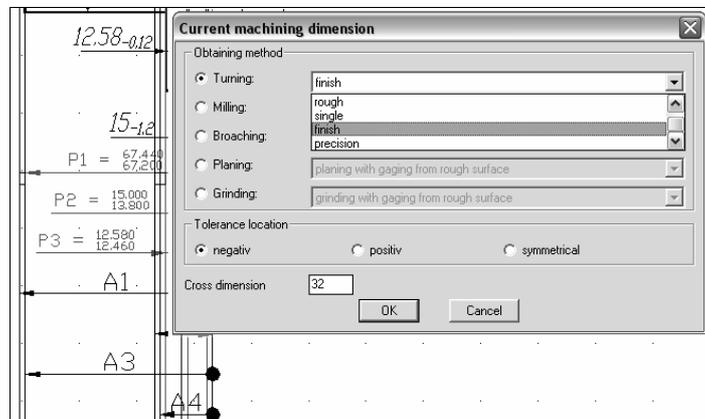


Fig.9

On completing the stage the system informs: how many dimensions were entered and whether the balance necessary for the correct chains analysis of the dimensions is observed. For cancellation of each stage constructions it is necessary to choose item "***Cancel last action***". If balance is observed, technological dimensions $A_i$, which are to be calculated, are automatically moved to the bottom part of the dimensional scheme, below the workpiece dimensions, and
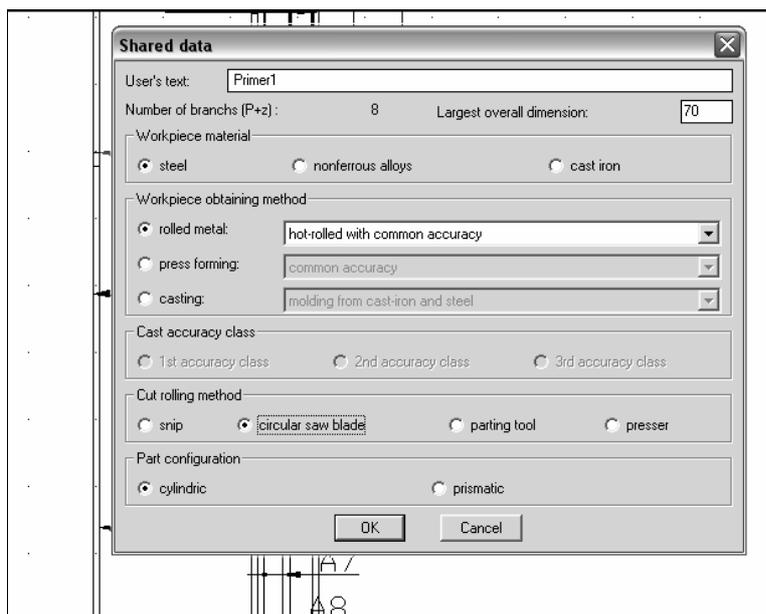


Fig.10
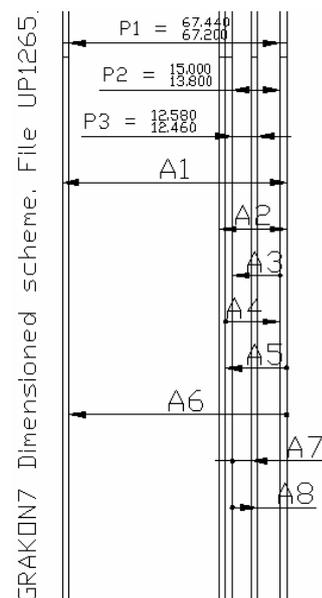


Fig.11

receive through numeration with workpiece dimensions chosen earlier. As a result the dimensional scheme of workpiece processing variant is obtained. After pressing the *OK* button of the information report, system **GRAKON7** offers to choose item "*Calculation*" from the menu **MDim**.

   The choice of this item causes the appearance of final dialogue window (Fig.10) where it is necessary to specify a method of workpiece obtaining, the greatest workpiece dimension etc. Input of this window is formed primary model (see Fig.2) of the dimensioned change the stocking up in the manner of dimensioned scheme (Fig.11) and secondary model in the manner of numeric array for module **KON7** [2]. In a course of the analysis of secondary model in program module **KON7** contours of dimensional circuits are revealed. The constructed equations concerning closing links are submitted on Fig.12.

```
                                                                         Table 2
     The results of denominate dimension chain's equation and consecution of its solution
   ---------------------------------------------------------------------------
   Solution|Unknown|        Equations in character form
      #    |branch |
   ---------------------------------------------------------------------------
      1    |  A8   | P2=+A8
      2    |  A3   | P3=+A3
      3    |  A4   | Z3=-A3+A4
      4    |  A7   | Z4=-A7+A8
      5    |  A5   | Z5=-A4+A5
      6    |  A6   | P1=-A5+A4+A6
      7    |  A2   | Z2=-A5+A2
```

Fig.12

The results of calculation of nominals and deviations of technological dimensions $A_i$ are shown on Fig.13.

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                                                                                 Table 3
   The results of dimension chains calculation with KON7 (C) Kalachev O.N., 2000 t.(0852) 475419
   ---------------------------------------------------------------------------------------------
   Closure branchs              |                    Component branchs - A:
   P-desigh dim., Z-allowance    |     workpiece dimensions <-->, machining dimensions O-->
   --------------------------------------------------------------kon7-116-120 D1 zz GRA-HA--
   Bran-|Surface| Limiting values |Bran-|Surface|                         |       | Deviations
   ch's | l  r  |-----------------|ch's | <-->  | Processing technique    |Nominal|--------------
   index|new old|  max  |  min    |index|base-->|                         |       | upper | lower
   ---------------------------------------------------------------------------------------------
   P1   | 2   8| 67.440| 67.200| A1  |  1   9|Press form. com accuracy | 70.100| 1.500| -1.000
   P2   | 5   7| 12.580| 12.460| A2  |  3   9|Press form. com accuracy | 17.460| 1.200| -0.800
   P3   | 5   8| 15.000| 13.800| A3  |  8   5|Turning finish           | 15.000| 0.000| -0.084
   Z1   | 2   1|  3.710|  1.130| A4  |  4   8|Turning finish           | 15.200| 0.000| -0.060
   Z2   | 4   3|  2.930|  0.830| A5  |  9   4|Turning single           | 15.830| 0.000| -0.100
   Z3   | 4   5|  0.284|  0.140| A6  |  9   2|Turning fr. rough surf.  | 67.970| 0.000| -0.080
   Z4   | 7   6|  0.594|  0.230| A7  |  5   6|Turning rough            | 12.266| 0.000| -0.280
   Z5   | 8   9|  0.690|  0.530| A8  |  5   7|Turning finish           | 12.580| 0.000| -0.084
   ---------------------------------------------------------------------------------------------
```

Fig.13

   The further actions of the technologist depend on calculation results of the variant of processing offered by the technologist. In particular, if chosen dimensional structure of technological process provides accuracy of the constructing dimension of part drawing, user can close AutoCAD 2002, having kept or having printed out results of calculation and received dimensional scheme. In this case the information of internal primary structural model of workpiece dimensional changes will also be kept, and work with it can be continued in the following session. Otherwise, analysing the information on each chain, the technologist can update data of generated before variant changing dimensional scheme and inputing from the dialogue windows in AutoCAD 2002 environment under **GRAKON7** management. In a given example the design dimensions accuracy is provided without updating structure of TP [3].

   Thus, using system **GRAKON7**, the technologist models part processing on the screen as dimensional structure, and in real-time mode receives the conclusion about expediency of technological process variant from the point of view of obtaining required accuracy of the design dimensions of a part.

   In summary we shall note, that besides direct purpose - dimensional analysis - the considered graphic system can become the basis for CAPP routing (operating) technology [4]. In difference from existing systems of designing in textual dialogue, for which the technological sizes should be known, in the offered approach dimensional accounts - basis of design process, making possible automatic formation of the operating sketches.

## References

1. Kalachev O. Development CAPP GRAKON7 on the basis of interactive construction in AutoCAD 2000 dimensional circuit of technological process of machining. 4-th international conference " Interactive systems: The problems of human-computer interaction ". Uljanovsk, 2001. - p.57-58

2. Kalachev O.N., Pogorelov S.A. Automation of dimensional calculations at a design stage of technological process machining // Bulletin of mechanical engineering. - M.: - 2002. - №6.- P. 54-58.

3. Kalachev O.N., Rehter A.D. Modelling of the sizes machining in AutoCAD 200x environment on the basis of use of application GRAKON7 // "CAD and the graphics". - M.: - 2002. - №2.-With. 100-104.

4. Kalachev O.N. GRAKON7. http://tms.ystu.ru

**Summary**

The place of the module of an estimation of adaptability to manufacture of a design of a product on a joint of systems CAD GRAKON7-KON7 is considered. The automated system for a quantitative estimation of parameters of adaptability to manufacture of a product and forecasting of labour input of its manufacturing is described. The contents of screens of system and structure of the menu is resulted.