# Formation of the Optimal Machining Process Based on the Analysis of Design and Technological Dimension Relations

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# Formation of the Optimal Machining Process Based on the Analysis of Design and Technological Dimension Relations

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## Introduction

Creating of the effective technology from a technical and economic point of view for all types of production is a complex task. Comprehensible quality of details in the conditions of traditional production (mass production, in a large batches production, batches production) is provided with their manufacturing on the adjusted machine tools with use of complex industrial equipment and special means of the control. It demands very careful technical and economic study of accepted technical and technological decisions.

Design decisions for a detail (the form, structure of surfaces, the sizes, accuracy, roughness and technical requirements) are accepted considering first of all functional requirements. At the same time the designer carries out the improvement of a detail on general adaptability to manufacture and makes changes to details without touching their functionality. As a result, there is developed and approved the working drawing of a detail and corresponding technical requirements concerning dimensional accuracy, accuracy of the form, accuracy of a relative positioning of surfaces, their roughness and other technical requirements.

To habitual until recently to conditions traditional production are adapted also the corresponding methods of designing of technologies. Usually, there is allocated a pretty short period of time for the technological preparation of manufacture and it is possible to consider only few variants of technology and to offer only one of them. This variant of technology represents the subject of improvement during application by revealing weaknesses in the conditions of the limited field of allowable technological decisions as the equipment is already provided, and adaptations and means of measurement are made. Technological processes of machining are developed after the design drawing of the detail by the functional criterion is done (the form, structure of surfaces, the sizes, accuracy, roughness and technical requirements) with improvement on the general adaptability to machining with changes without touching functionality, after approbation of the detail's working drawing and includes the consecutive decision of a series of tasks [1]:

- the analysis of the design drawing of a detail and of its technical requirements;
- improvement on adaptability to machining with offers on changes without touching functionality;
- choice of a method of formation, kind, the form of the blank and her accuracy;
- choice of number of technological operation elements and sequences at machining of the basic surfaces of a detail;
- division of technological process into stages (rouging and finishing);
- formation of variant of the plan of operations;
- the dimensional analysis of the variant of technology;
- choice of the machining equipment;
- choice of adjusting and measuring bases;
- development of operational sketches and of technical requirements on operation of the technological process;
- calculation of machining allowances, of the operational sizes and its tolerances;
- calculation of cutting conditions, the norming of technological operations;

- the economic analysis of the technological operation;
- formation of the technological documentation.

The analysis of a working drawing of a detail and technical requirements is carried out by the technologist and it has mostly a familiarization character, since it basically aims the elements of a detail design and as a matter of fact it can be only superficial as the working drawing is already authorized and serious grounds are necessary for its change, and they are still not present.

The dimensional analysis of technological processes according to [2, 3] is carried out at late development stages of technology and actually has a checking character and has low efficiency. In the case of revealing discrepancies the new variant of technology without special guarantees on achievement of qualitative result is developed. The satisfactory result is achieved for some iterations. The big labour input of the process of constitution of the schemes of dimensional technological links and of the dimensional analysis leads to increasing the time of technology development, to reception of an acceptable but not optimum from the point of view of sizes accuracy assurance variant of technological process. The big lack of such approach is the fact that the dimensional structure of a detail is taken into account insufficiently and practically is not analyzed. If such analysis nevertheless is carried out, it has an ascertaining character.

**The dimensional development of machining technologies**

In modern multi-nomenclature manufacture high quality of details is provided with their machining on programmed CNC machine tools, including, processing centers. Often change of machinable details leads to shortening the time for technological preparation of manufacture, and the time factor is determining. The small seriality does not suppose the effective development of technologies at trial machining even several details. Therefore the qualitative technological processes should be developed by use of the new improved techniques.

The analyzed method differs from the previous that provides mutual rapproachement of two processes with what are design and technological designing. The analysis on adaptability to manufacture is carried out in common by the designer and the technologist and, thus there is possible a greatest rapproachement of design features of a detail and features of technological systems used. The last have ability of morphological transformation, in other words, ability to change the structure in full conformity with the current technological needs of machinable details.

The multifunctional modern equipment also allows to form a complex of surfaces variously located from each using other various methods of processing. The problem of the sizes accuracy assurance is solved once using the principle of unity of basing and at the expense of the effect of errors compensation.

The new approach of technological processes' development provides replacement of the dimensional analysis of variants of technological process by the dimensional designing of technological process. And it is possible only in a case when the technological dimensional analysis is carried out at a development stage of constructive design of the detail. In other words, technological preparation of manufacture should begin at the stage of designing a product, development of working drawings of details and their technological analysis. The technological analysis of the drawing of details should not only ascertain the possible problems at manufacturing but also actively prevent their occurrence.

One of criteria of this optimality has a structural nature. The manufacturing process is considered optimum, if in the structure of all technological dimensional chains, the number of the technological sizes is minimum [4]. This condition is respected if for each design size the unique technological size corresponds within the technological dimensional chain (Fig. 1), and in dimensional chains for machining allowances, each machining allowance is determined by two technological sizes or one technological size and one size on blank (Fig. 2).

At use of the graphs of technological and design linear dimensional links the condition of optimality is observed if evocative graphs are similar as shown in an example on Fig. 3. On modern machine tools the forming of the sizes is possible from a technological contact base (***TCB***) and from technological adjusting bases (***TAB***). Technological adjusting bases can be many (***TAB1***, ***TAB2***, ***TAB3*** etc.) and they should be used in the coordinate order.

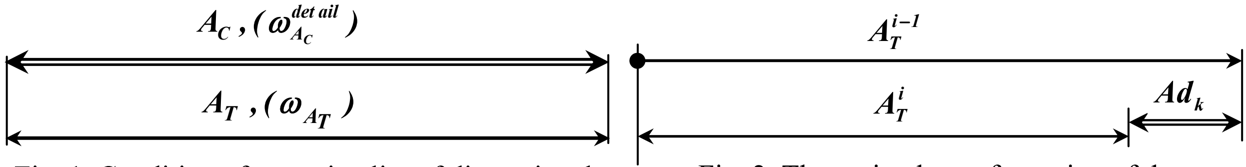


Fig. 1. Condition of an optimality of dimensional links - the design size is submitted only by one technological size, $\omega_{A_C}^{detail} = \omega_{A_T}$

Fig. 2. The optimal transformation of the technological sizes – from the technological base, $\omega_{Ad_k} = \omega_{A_T^{i-1}} + \omega_{A_T^i}$

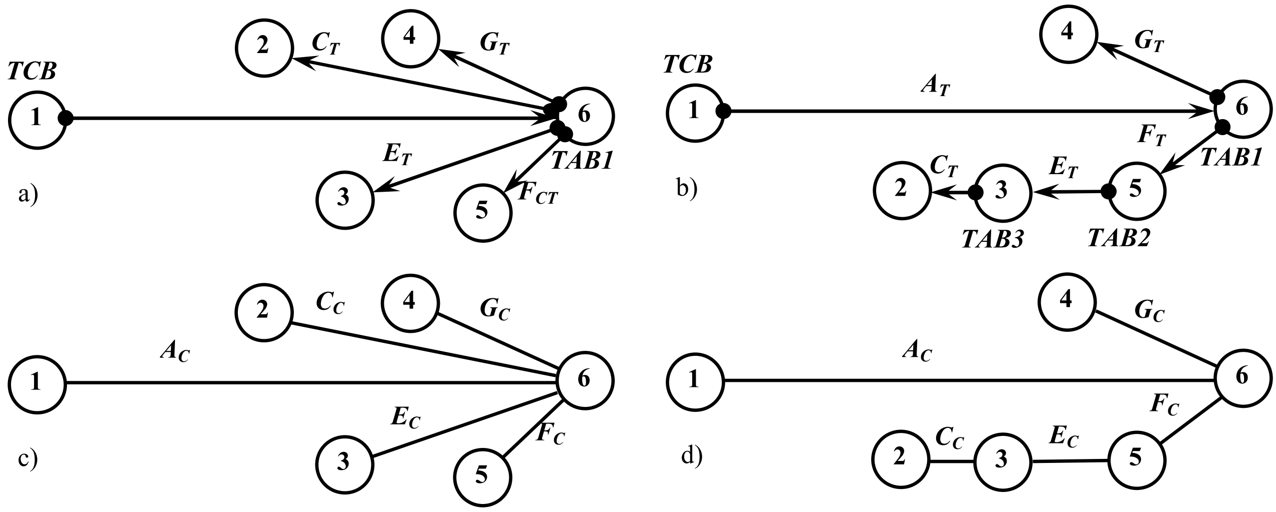


Fig. 3. Similarity of the graphs - criterion of the optimality of the machining operations: a), b) - examples of the graphs of technological linear dimensional links ($X_T$) corresponding to dimensional structures of the machine-tools with forming of the sizes from a technological contact base (TCB) and from technological adjusting bases (TAB); c, d - the graphs of design linear dimensional links ($X_C$) similar to the graphs of technological linear dimensional links. 1…6 – the number of the surfaces.

In practice the sizes of details are directed on assurance of functionality and the similarity of the graphs is quite often possible to provide only by detail's resizing (Fig. 4, Fig. 5). The solution in this situation is the change of the constructive sizes on a line with a lower accuracy. In Fig. 5 conditionally this line is the line 6 - 4 - 2 since growth of accuracy of the sizes $G_C$ and $C_C^*$ is less significant in comparison with the growth of accuracy of the respective sizes by the line 6 - 5 - 3. More complex is the assurance of similarity of design and technological graphs at use of machine tools such as machining center with a rotary table (Fig. 5). The axis ***0*** of a rotary table is the technological adjusting base (***TAB0***) and conducts to formation of the technological sizes $A_{T1}$ and $A_{T2}$. Accordingly, after resizing the detail will have the design sizes $A_{C1}$ and $A_{C2}$. Besides the basing of a detail is carried out on some surface ***X*** which position is determined from other functional surface of a detail. And in this case the resizing of the detail with use the technological adjusting base ***TAB0*** is imminently necessary.

It is necessary to note that the technological operations are carried out with use of the blank or of the details in progress. And the blank and the details in progress are the finite entities with the own systems of the design sizes. Thus, the design dimensional links do not concern exclusively to a detail. In the beginning it is the blank's design dimensional links, then - the design dimensional links of the detail in progress and in the end - the detail's design dimensional links.

Thus, the dimensional designing of technological processes results in optimality if it is possible to achieve the similarity of design and technological dimensional structures in the following order:

- creation of the blank's dimensional structure similar to the detail's dimensional structure;

- formation of optimum technological dimensional links of the first technological operations (roughing) by resizing if necessary of the blank and of the detail;
- formation of optimum technological dimensional links on the subsequent technological operations by resizing if necessary of the detail in progress;
- formation of optimum technological dimensional links on the final technological operations by resizing if necessary the detail;
- calculation of the minimal machining allowances;
- the dimensional analysis of technology with calculation of the operational sizes, their tolerances and limit deviations;

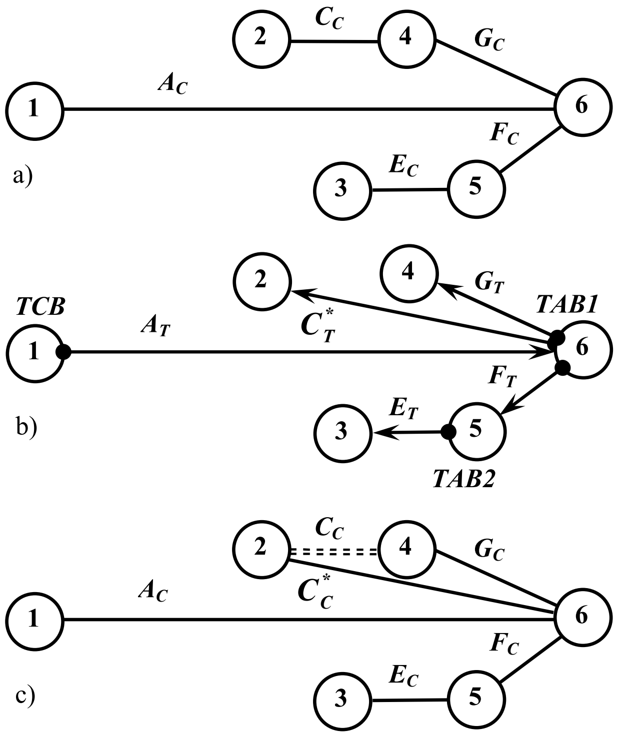


Fig. 4. Example of similarity's assurance of the graphs for an optimality of machining operations on lathes by means of detail resizing: a) the graph of linear design dimensional links; b) the graph of linear technological dimensional links; c) the graph of linear design dimensional links after resizing

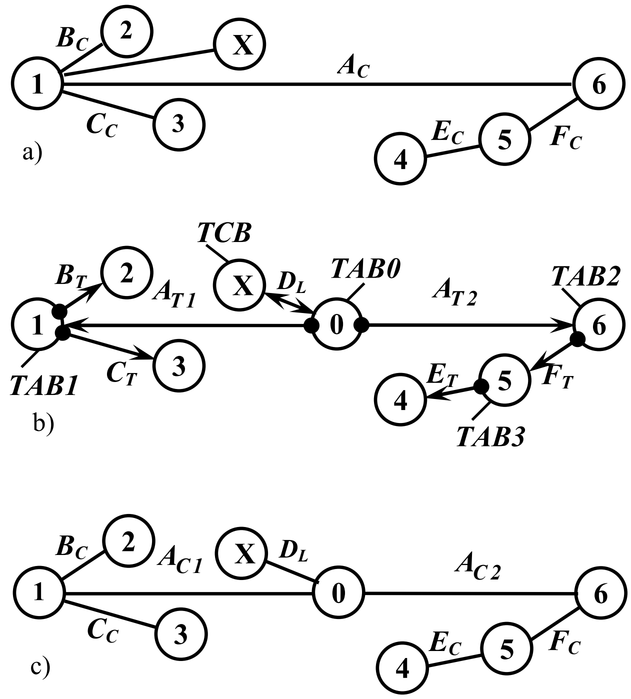


Fig. 5. Example of similarity's assurance of the graphs for an optimality of machining operations on machine tools of the type machine-center by means of detail resizing: a) the graph of linear design dimensional links; b) the graph of linear technological dimensional links; c) the graph of linear design dimensional links after resizing

- formation the drawings of the blank.

The scheme of development of machining technology in which the dimensional analysis is carried out at early stages in Fig. 6 is shown.

## Conclusions

Analysis carried out in this paper suggests some obvious conclusions:

- the traditional method of designing of the machining's technologies to a small degree is directed to guarantee the achievement of the parameters of quality;
- the modern techniques of development of the machining technologies are based on principles of the concurrent engineering and considerably earlier application of tools of the dimensional analysis;
- the method discussed in the work is directed to application of a technique of the dimensional analysis as a tool of dimensional designing;
- for guaranteed assurance of dimensional accuracy it is necessary to adapt mutually the technological dimensional structures of operations with design dimensional structures of entities (preparation, a detail in process, a detail) received after the previous operations including-resizing of these entities.


Fig. 6. Process of dimensional designing of the machining technologies

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