Optimality of the Machining Process Based on the Mutual Influence of Design and Technological Dimension Relations

Article *in* Advanced Materials Research · October 2014

DOI: 10.4028/www.scientific.net/AMR.1036.1033

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Optimality of the Machining Process Based on the Mutual Influence of Design and Technological Dimension Relations

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Keywords: dimensional analysis, optimum dimensional structure, machining accuracy, similarity, technological mounting, concurrent engineering.

Abstract. In the given work it is shown, that at machining the technological dimensional structures are optimum if they are similar to the design of the dimensional structure of a detail. The conditions of locating and fastening, and also some technical requirements interfere to achieve similarity. In these cases the directed change of the design of the dimensional structure of a detail is recommended due to recalculation of the sizes. From this point of view creation of technological process represents a compromise of mutual approach of the dimensional structures of a detail and of a technological system. The most appropriate entity as element out of which the technological process may be built is a technological mounting. The mounting has a dimensional structure and includes communication elements - the sizes up to locating surfaces.

Introduction

The existing classical methods to design technological process are complex and do not provide the required level of quality and reliability of technologies. The theory of manufacturing engineering to design the technology has a well-developed content part, but it is not sufficiently formalized. The attempts to automatize the process of developing technology based on the typical technologies are severely limited and are applied for relatively simple standard parts [1]. The designing processes for more complex parts and for conditions of use of the CNC machine tools is more challenging in terms of both general approach and from the point of view of formalizing the process used and logical-mathematical apparatus.

The design process of the technologies should be considered more perfect if it requires a smaller number of information changes, including a smaller number of iterations. The technological process should be considered more perfect when it requires for use a smaller number of transformations of matter and energy which are also displayed via the relevant information.

In the development of technologies there can be identified two different objective functions:

- technical goal which function is to ensure the required quality of the processing results, this goal function can be achieved in various variants of the technology;
- economic goal which function is to achieve the minimum processing's costs, this goal function leads to the need to choose from a variety of technology options to one that fits the best the accepted economic criterion.

The presence of two goal functions leads to separation of the design process in two main stages. During the first one the generation of the technology options is carried out in accordance with the technical goal function. During the second one the choice of a variant is carried out on the grounds of economic objective function.

In the development of the technological process as the original model chooses the created plan of operation and the dimensional structure of the process [1, 2, 3]. The model is a set of consecutive sketches that reflect the expected state of the work piece at all stages of processing. The task of the system is to determine the sizes of these successive states using dimensional analysis techniques.

Using the machine tools such as machining center puts forward new requirements for the process of the design technologies. In contrast to the conventional and traditional method in which the technologies are developed in advance, in this new situation the technology must be developed immediately before starting the production. Thus the design of technology becomes situational [4], and the elements that make up the technological process are not the operation, which is based on the organizational principle but operation elements the nature of which is purely technical. In the synthesis of the technologies between these elements, the appropriate connections are set corresponding to the structural characteristics of the work piece.

Design of machining technologies within the concept of concurrent engineering

The concept of Concurrent Engineering is one recognized while simultaneous designing of machine parts and the processes of their machining. Favorable conditions for this exist when creating a 3D assembly from separate details (3D models) but the structure and whose parameters including dimensions and accuracy may undergo changes.

In fig. 1 are shown the schemes reflecting the differences between various methodologies of design: sequential (linear), the pseudo-Concurrent Engineering and true-Concurrent Engineering.

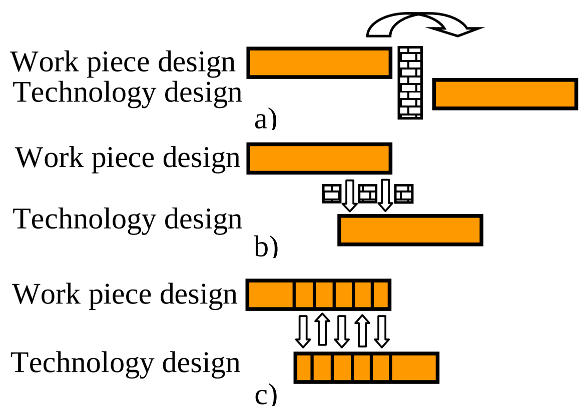

Fig. 1. The methodologies for technologies' development a) linear; b) simultaneous – pseudo Concurrent Engineering; c) true Concurrent Engineering

The linear scheme of designing has an information barrier associated with the incompatibility of information or the information is represented in the different models etc.

Pseudo Concurrent Engineering scheme allows some overlap in time of project activities in relation to the piece and technology. At the same time, there is a variety of information barriers that stifle, slow down the exchange of information or the information has a high degree of variability.

Truly Concurrent Engineering methodology is characterized by the lack of any kind of information barriers. Moreover, the constructive elements of details and the elements of the technology have a high level of informational completeness and the variability refers to the interconnected parameters.

For realization of an effective process of technology development within the framework of Concurrent Engineering it is necessary to achieve the results for the individual steps and the images of their information in accordance with the principles of axiomatic design: independence of the output parameters and minimal information content.

Thus, the most important task is to determine the entities of details on the one hand and appropriate entities of the technology on the other hand between which there is a connection and interaction.

The technological process, being a system, includes its own subsystems on the next level of decomposition - manufacturing operations. The decomposition process can be continued further by highlighting mounting, working position, operation element etc.

The informational interaction between the piece and the technological system can be traced by analyzing the description's levels of the detail and of the technological system. Any technical object can be described functionally, structurally and technologically (fig.2). The functional description defines the content of the constructive (structural) description and the last in turn - the technological description.

It can be argued that the design of the technological process initially acquires the character of a description of what should happen with a detail in the process of its transformation from a blank - the technological aspect of the piece. The preferred way to do this is by establishing a pair of "surface - the operation element" in reverse chronological order, i.e. from the finished detail. This process is more uncertain when applied to the surfaces of the blank because the blank has a structural and qualitative variability depending on the method of obtaining. At this stage, the impact of the equipment's characteristics on the characteristics of operation elements is taken into account, however, in the computer-aided design the multiplicity of options makes it difficult. As mentioned above it is very important to follow the principles of axiomatic design.

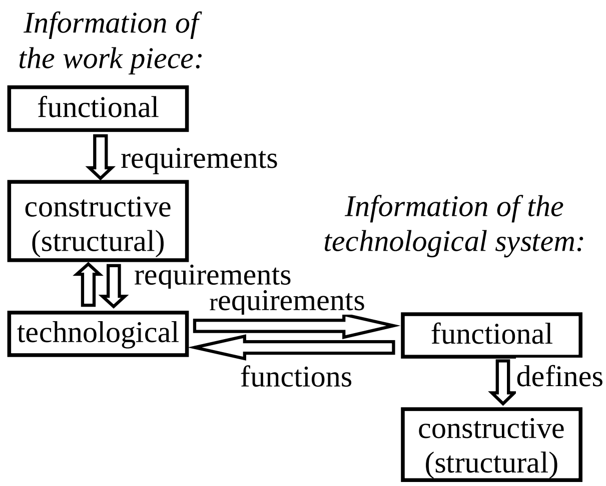

Fig. 2. The relationship between the information of the work piece and the created technological system

The technological description of detail stated in the form of requirements for the technological system, and thus formed a functional description of the latter. Based on this a constructive description of the technological system was developed. Note that the technological system may be made from various machine tools so that well formed functions in response to the technological requirement of the piece. At this stage the technological process acquires the character of a description of what and how should execute the technological system with the piece in the process of its transformation from a blank - the functional aspect of the technological system.

Technological process may be built from operation elements, but they (the operation elements) do not have the necessary characteristics to create the dimensional structures. These characteristics are not formed during decomposition because the relevant details dimensional structure is not taken into account.

The most appropriate entity as element of which the technological process may be built is technological mounting. The mounting has a dimensional structure and includes communication elements - the sizes up to locating surfaces

In fig. 3 a diagram of formation of the design and technological descriptions of the work piece in the process of transformation is shown.

The general direction of creation of optimum technological processes is the similarity of the graphs of the constructive and technological dimensional links for each mounting. The variety of dimensional structures of details, the variety of technical requirements, the distinction of technical requirements for the surfaces make the process of achievement of similarity of the graphs difficult.

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 their own systems of the design sizes. Thus, the design of dimensional links do not relate exclusively to a detail. In the beginning it is the blank's design of dimensional links, then - the design of dimensional links of the detail in progress and in the end - the detail's design of dimensional links.

Conclusions

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:

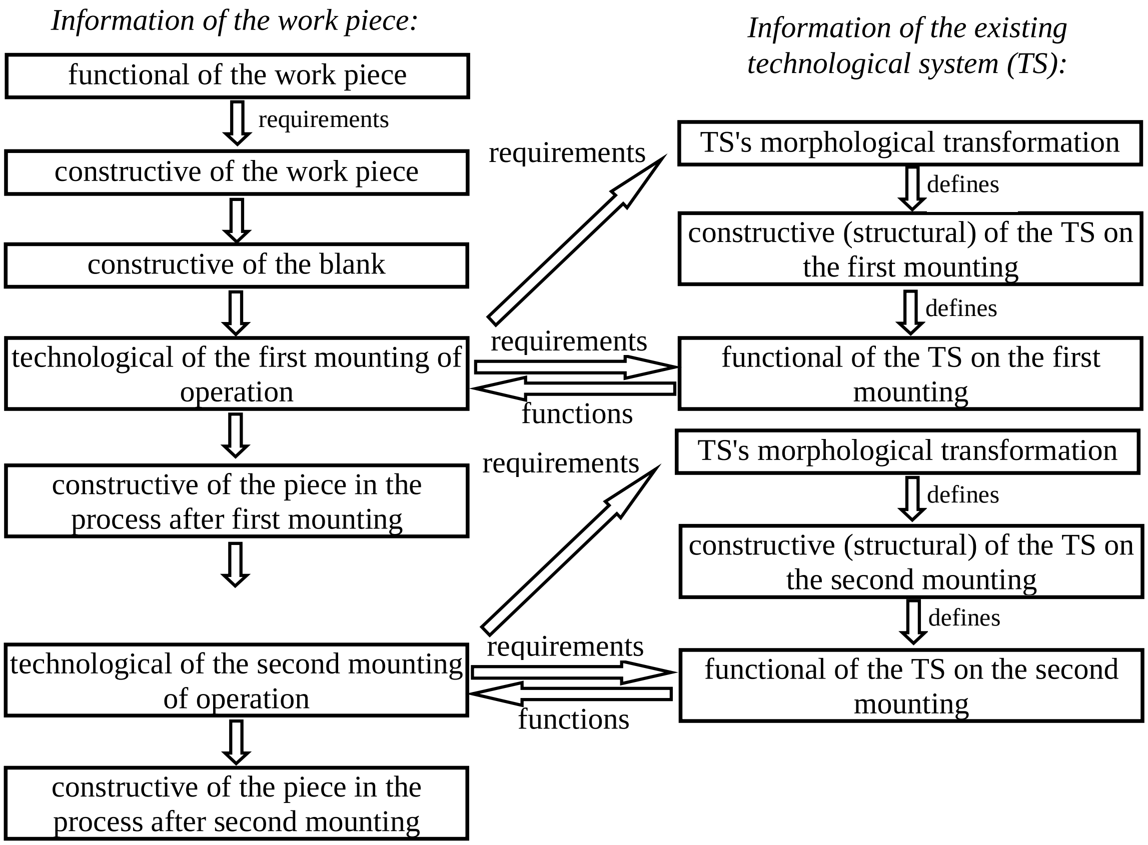

Fig.3. The relationship of the information flow at the design of the technological operation consisting of two separate mounting

- creation of the blank's dimensional structure similar to the detail's dimensional structure;
- formation of optimum technological dimensional links of the first technological operation or mounting (roughing) by resizing if necessary of the blank and of the detail;
- formation of optimum technological dimensional links on the subsequent technological operations or mounting by resizing if necessary of the detail in progress;
- formation of optimum technological dimensional links on the final technological operations or mounting 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 and formation of drawings of the blank.

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