Dialogue system for designing technological processes

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Abstract. The paper deals with the issues of automation of technological design, for which it is proposed to introduce the concept of a structured reference space of a technological process, which is understood as a special design created on a set of processes used in the manufacture of products, on which their ratio is set for individual subsets of the materialization processes of a product. To describe the reference space of the technological process, a method for solving methodological and mathematical problems is proposed - according to the information image of objects and processes; analysis and synthesis of processes; synthesis of equipment layout diagrams; machine methods of systematization. The latter made it possible to develop a qualitatively new approach to organizing data on technological processes, based on an object model for representing and processing information. Keywords: design automation, technological process, reference space, object model, database.

1 Introduction

In the field of automation theory, the design of technological processes, many works and systems are known. However, the tasks of technological design are so complex and diverse that only with the advent of modern technologies for integrating various CAD/CAM/CAE/PDM systems does it become possible to implement them in the aviation industry.

Automated systems differ significantly in the type of technological problems being solved, the design models used, and the role of the designer in these systems. Calculation problems are most successfully solved (calculation of cutting conditions, allowances, time standards, dimensional chains, etc.), which are part of the process of technological design. The tasks associated with the formation of structures of technological processes are most often solved on the basis of typing and do not always provide the necessary and optimal solutions. The systems for designing machining technologies are most widely used [1].

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2 Model and method

Consider the popular VERTICAL system developed by ASCON [2].

The following TP design methods are implemented in the system:

- Designing on the basis of the technical process-analogue;
- Design using a library of frequently repeated technological solutions;
- Design using the CHP library;
- Borrowing technological solutions from previously developed technologies;
- Interactive design mode using system databases.

The CTE tree displays the composition and hierarchy of the surfaces of the part. Selecting a specific element in the tree automatically collects technological transitions for this structural element of the part and displays them on the "Processing plan" tab.

Access to electronic reference databases is an integral part of the work of a technologist in computer-aided design of technological processes. Moreover, in order to use design systems, users have to form these databases themselves or hire programming specialists and do a lot of work to update the databases in accordance with production changes [3].

MAI has developed an interactive process design system based on the use of Microsoft Office Access. This system can be successfully used both in the educational process and for small and medium-sized industries. Microsoft Office Access. - a powerful editor, which is a database management system based on the relational model. It should also be noted that it uses a dynamic exchange model between network resources and applications. At the same time, the editor uses advanced tools to process any type of information and present them in a clear, consistent structure [4].

Technological knowledge, like any other, is acquired in the process of active scientific and production-cognitive activity of a person. Having passed the stage of systematization, they form a technological knowledge base. Usually, the systematization of technological information is carried out in the form of reference materials, instructions, standard processes, etc. Such information is adapted for the manual design process [5-6]. When designing technological processes, the most complex tasks of process formation are the tasks of determining the necessary operations, the sequence of operations, the sequence of transitions. In the MAI dialogue system, these tasks are solved (briefly) on the basis of a complex classification in the following sequence:

1. A block diagram of the technological process is selected (based on a complex classification).
2. For each particular process, possible operations are selected (operations are grouped into stages in advance).
3. The sequence of operations is determined. (Information is entered into the route map.
4. Equipment is selected from the database (entered into the route map).
5. For each operation, transitions and their sequence are determined).
6. For each transition, a typical processing scheme is selected and cutting conditions, time standards are calculated. (Entered information in transaction cards).
7. Similarly, technological equipment (device, measuring and cutting tool) is selected from the databases for each transition.

3 Research and results

Let us consider in more detail some, but important aspects of the construction dialogue system [7-8].

Structural diagrams are nothing more than generalized ordered sequences - the processes of manufacturing aircraft parts (typical manufacturing scheme). On Fig. 1 gives an example of a block diagram for the manufacture of parts of the 2nd complex class.

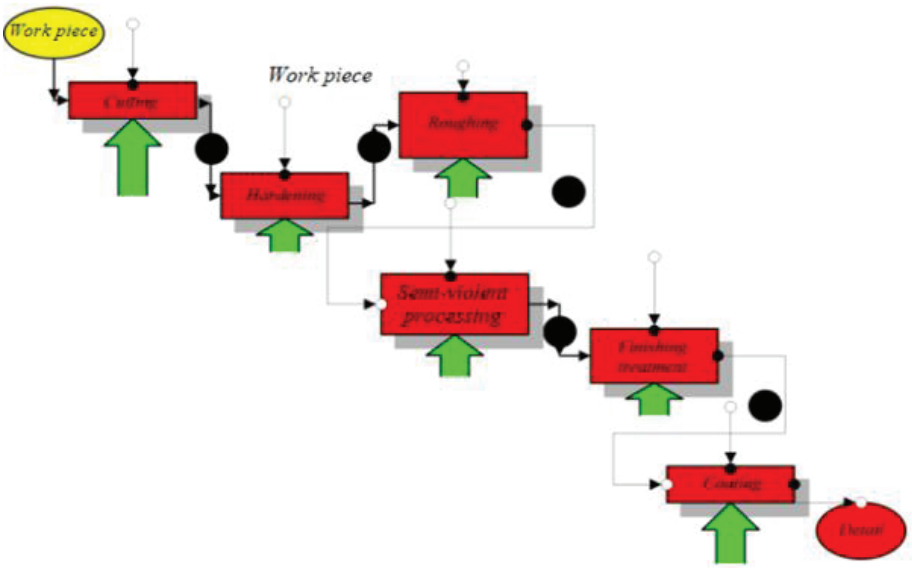
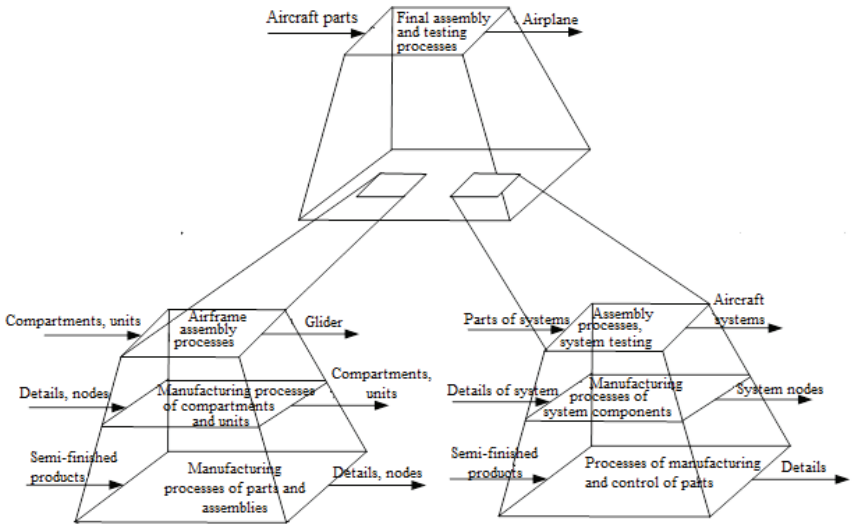


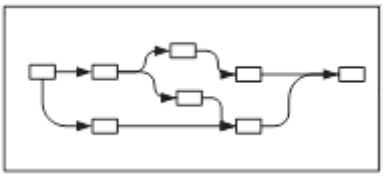
Fig. 1. An example of a block diagram for the manufacture of parts 2nd complex class.

Thus, at the levels of groups of private processes, these structural schemes are invariant to specific production conditions. This property of block diagrams allows us to put them as initial information in the basis of the development of systems for designing the processes of manufacturing parts [9-10].

An integrated approach allows us to approach the construction of a perspective form of specifying the support space in the form of structured technological schemes for the manufacture of a complex product (Fig. 2.) and move on to the development of fully automated design systems [11].



a)



b)

Fig. 2. a) Support space in the form of structured, typical technological schemes for the manufacture of a complex product; b) Structural diagrams for each level for given subsets of products with certain properties.

Under the structured reference space of technological processes of materialization of a product, we mean a special construction created on a set of processes used in the production of products, on which an order relation (strict or non-strict) is specified for individual subsets of processes [12-13].

The design of the supporting technological space must have the following properties:

1. be a hierarchical system and be characterized by: vertical decomposition into subsystems for solving technological problems at various levels of abstraction;
2. have full or partial orderliness of processes at each level;
3. allow the possibility of using systematized processes for automated design of materialization processes for a particular product.

The construction of such a complex structure as a supporting technological space requires the resolution of methodological and mathematical problems - on the informational image of objects and processes; analysis and synthesis of processes; synthesis of layout schemes of equipment; machine methods of systematization [14].

The design of the reference technological process and its further use in automated design systems requires the use of mathematical models of the information image of processes and objects.

For an informational image of processes and objects and, ultimately, for the construction of a supporting technological process, models of a special type are required - system-multiple, since not just a process model is being built, but a model of a set of processes, a set of structures, a set of objects, etc. When building such models methodological issues are put forward in the first place - logical and philosophical aspects, principles of structuring processes and objects.

The principle of structuring processes and objects. The system approach, which is the methodology of modern studies of large systems, involves a comprehensive consideration of processes and objects: consideration of the process as a holistic formation; identification of constituent parts and relationships; analysis of the functions of parts and functional relationships between parts; a reasonably expedient degree of informational description of a process or object.

The ultimate goal of system analysis, taking into account the logical and philosophical aspects, is the construction of system-multiple mathematical models for practical use.

The principle of regularity. There are regular structures of technological processes, regular structures of technology objects, regular relationships and functional relationships between processes and objects that allow for a preliminary systematization of design technological knowledge.

Process decomposition principle. The technological process as a complex system can be decomposed into sub-processes or objects and actions.

Another form of process decomposition is the selection of items involved in the process, according to the scheme:

Items => action name, where => relationship "items participate in the process".

Objects, in turn, can be considered as integral formations and decomposed into parts, while considering the properties of the parts, the connections and relationships between the parts that form the whole. Consideration of objects as integral systems and their decomposition makes it possible to form classes of objects, perform a detailed analysis of the presence of properties, relationships, qualities, and ultimately build an information image of objects or parts.

When operating with idealized objects, a number of conditions are used.

Condition 1 (following processes, objects).

If the properties of processes (objects) are in relation precedence, then processes, objects follow each other:

$$\forall v^{l-2}, \exists v_2^{l-2} \exists v_1^3 (v_1^{l-2}) \exists v_2^3 (v_2^{l-2}) [v_1^3 (v_1^{l-2}) \wedge$$
$$\wedge v_2^3 (v_2^{l-2}) \wedge R_2 (v_1^3, v_2^3) \rightarrow R_1 (v_1^{l-2}, v_2^{l-2})]$$

Condition 2 (object predeterminations).

If the properties of the first object require the presence of the properties of the second object, then the presence of the first object predetermines the presence of the second object.

$$\forall v_1^2 \exists v_2^2 \exists v_{11}^3 \exists v_{21} [v_{11}^3 (v_1^2) \wedge v_{21}^3 (v_{21}^2) \wedge$$
$$\wedge R_3 (v_{11}^3, v_{21}^3) \rightarrow R_3 (v_1^3, v_2^3)]$$

The system of meaningful conditions is added to the usual logical axioms of the theory of the first order of the predicate calculus and allows us to formulate a number of theorems that are the basis for the development of algorithms.

The above model of the reference technological space and the mathematical model that implements it, allows, using information technology, to build a computer-aided design system.

The databases of the technological process design system can be implemented on a qualitatively new approach to organizing data on technological processes based on an object model for representing and processing information. The process design dialogue system consists of the following interrelated objects (Fig. 3).

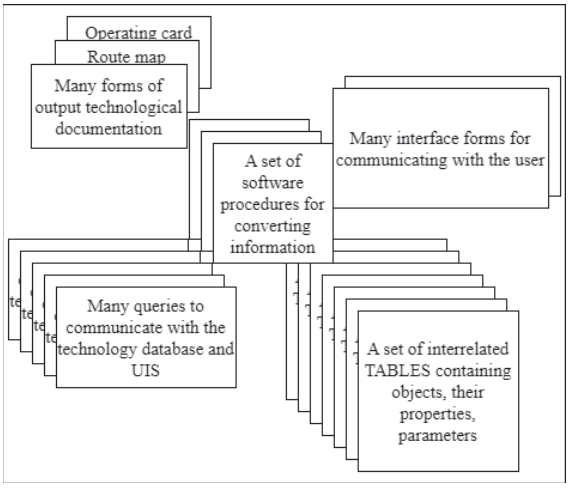


Fig. 3. The composition of the objects of the dialog multilevel, multiuser process design system.

New tasks require new approaches, primarily in the field of data presentation. Object-oriented methods of organization of technological databases, new interface solutions, open architecture are fully implemented in this system.

On Fig. 4 shows the IDEF1X model of interrelated system tables used in the formation of route technology in the design of technical processes.

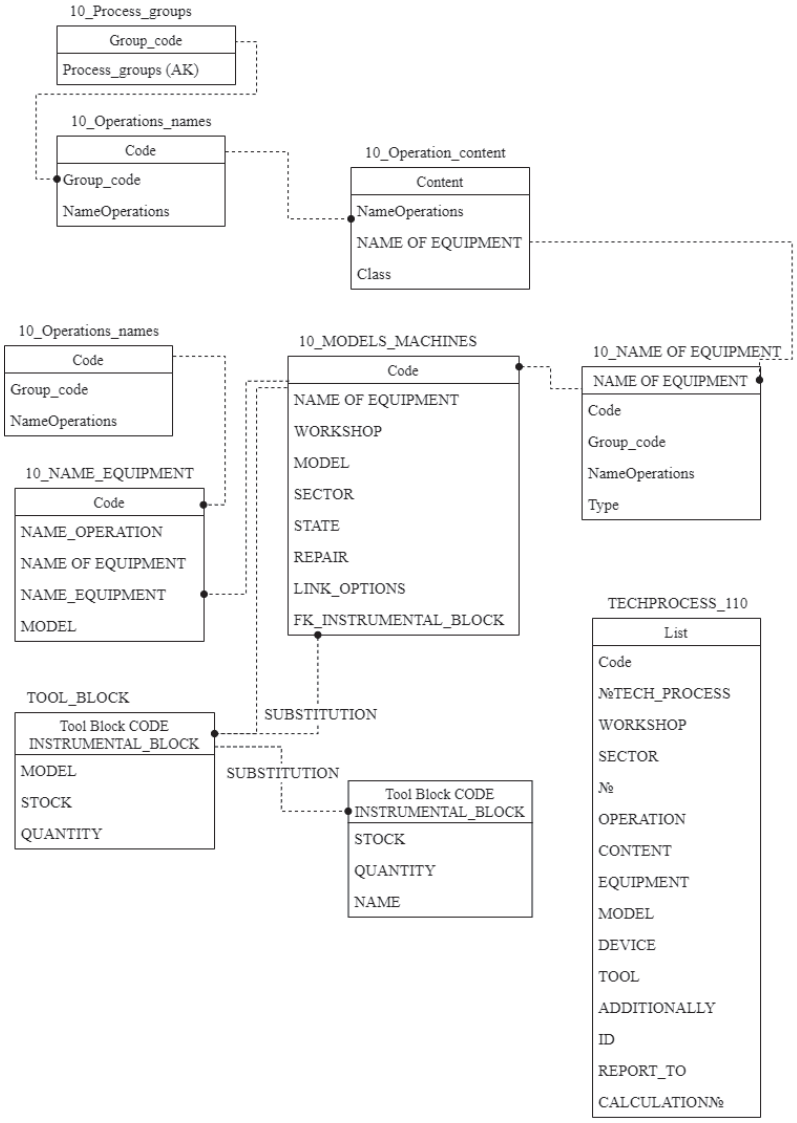


Fig. 4. Fragment of the IDEF1X model systems for designing technological processes.

Fig. 5 shows fragments of typical surface treatment processes during turning, and in Fig. 6 is a typical scheme for the formation of transitions during finishing turning.

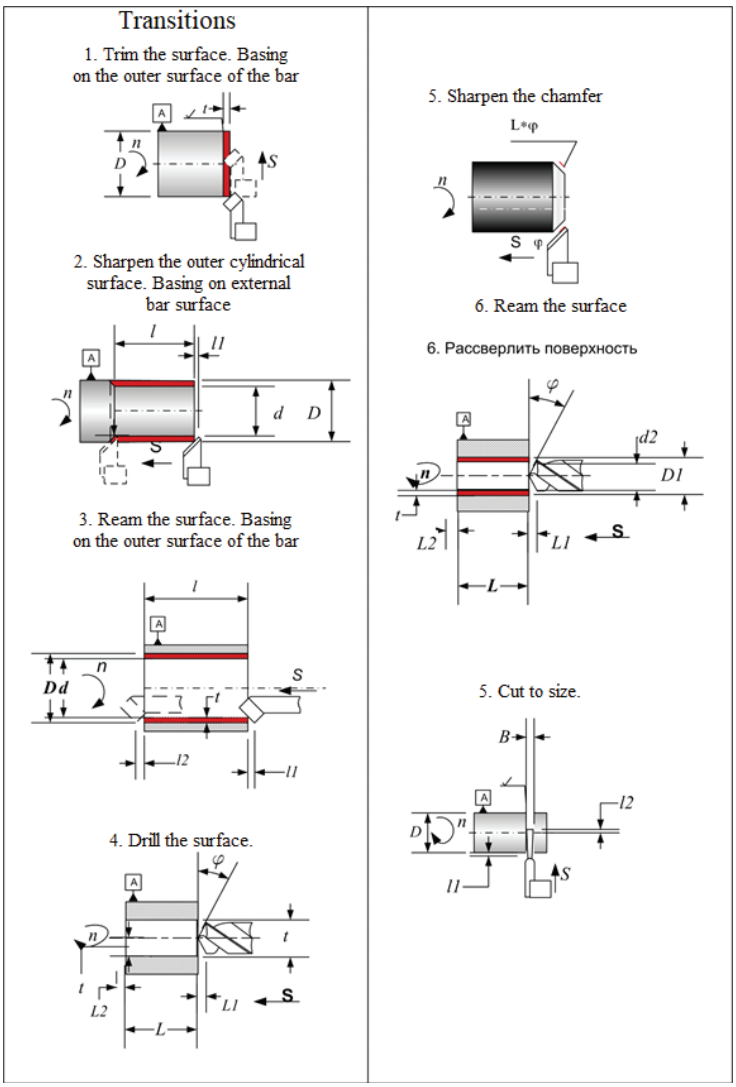


Fig. 5. Typical processes of surface treatment during turning.

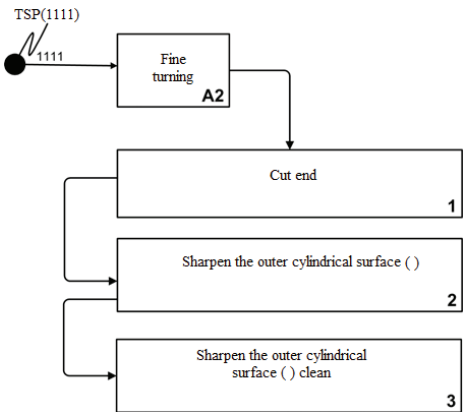


Fig. 6. Typical scheme for the formation of transitions during cleaning.

4 Conclusion

Using the methodology of modern studies of large systems, a comprehensive review of processes and objects as a holistic formation was carried out, after which the functions of the parts and functional relationships between them were identified and analyzed, which, in turn, made it possible to substantiate the appropriate degree of informational description of the process or object. Based on the analysis, a model of the reference technological space and a mathematical model that implements it were developed, and object-oriented methods for organizing technological databases and new interface solutions make it relatively easy to implement using Microsoft Office Access and use it to design technological processes in small and medium engineering enterprises.

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