Automation of design of technological processes

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Abstract. The article considers the majority of modern foreign and domestic CAD TP, which solve many problems of technological preparation of production. However, in most systems, the used method of automated design of technological processes remains incomprehensible, the existing organizational structure of pre-production is not taken into account, the correction of actual data (cutting conditions, time standards) does not meet the requirements of modern aviation production. The article proposes to actively use the integrated design method in CAD TP systems.

1 Introduction

Labor intensity and cost of technological preparation of production (TPP) is growing from year to year. The increase in the complexity of the TPP is caused by the following reasons:

1. Devices and machines are becoming more complex, new materials are being used, and ever higher precision in the manufacture of parts and assemblies is required.
2. Under the new conditions, it is necessary to develop a detailed operating technology and draw up control programs for CNC machines and automatic lines [1].
3. designing high-quality, optimal technological processes is becoming more and more difficult, since for this it is necessary to design hundreds, and sometimes thousands of variants of technological processes and select a process that meets the requirements of the designer and production [2].

Without automation, the technologist is not able to perform such a volume of work.

Often the development of technological processes is subjective and the quality of the designed technological processes depends on experience and technologist qualifications.

However, the tasks of technological design are so complex and diverse that only with the advent of modern CALS technologies with various CAD/CAM/CAE/PDM systems does it become possible to implement them in the aviation industry [3].

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2 Model and method

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 [4]. 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 technologies for machining and assembly are most widely used (Table 1).

Table 1. Systems for designing technologies for machining, assembling

№	System name	Firm developer	System characteristic
1	"SKAT PP"	University of Oil and Gas named after I.M. Gubkin	Technological preparation for the production of measuring tools, as well as a method for its automation using the SKAT PP system
2	"Pace"	Research and Production Center "Technologies of IPI" JSC "NICh "MATI"	1. Automated formation and analysis of technological electronic models of products; 2. Design and standardization of enlarged and working technological processes; 3. Visualization of the technological process using electronic layouts; 4. Formation and maintenance of the information environment of technological design; 5. Formation of sets of technological documentation.
3	"Temp-2"	Research and Production Center "Technologies of IPI" JSC "NICh "MATI"	Methodology for designing electronic technological processes.
4	"KOMPAS - Autoproject" – Specification sTechnology	ASCON	The KOMPAS-Autoproject software package consists of two interconnected subsystems: KOMPAS-Autoproject-Specifications and KOMPAS-Autoproject-Technology. In the first of these subsystems, technological tasks associated with the composition of the product are concentrated, and in the second, with the design of technological processes. Such a construction scheme is dictated by the need to integrate the technological module with PDM systems, both internal and external. To date, the KOMPAS-Autoproject-Technology program has been successfully integrated with the PDM systems KOMPAS-Manager and PartY Plus.
5	ADEM system	Group of companies ADEM "CherryCAD", Katran The main product of the ADEM group of companies is the ADEM-VX integrated CAD/CAM/CAPP/PDM system.	Design, modeling and construction; Development of design documentation in accordance with ESKD (drawings, single and group specifications, design change notices, specification sheets, bills of purchased products, etc.); Ensuring the manufacturability of the product design; Planning and management of the CCI product process; Development of product manufacturing routes; Design of technological processes Tooling and tool design; Development of control programs for CNC machines; Rationing of basic materials; Rationing of labor costs; Issue of technological documentation; Issuance of technology change notices.

6	TechnologiCS	ZAO "SiSoft Development" (Russia)	The main functional modules of the TechnologiCS system are: • module for maintaining directories and normalization of basic data (MDM); • project management module for putting new products into production, introducing innovations, detailing them to the level of work and tasks with the possibility of subsequent control over execution (Project Management); • product data management module (PDM), which performs the following functions: 1. ensuring the work of the designer with all the functions of the system directly from his design environment using the TechnologiCS panels built into the most commonly used mechanical engineering CAD systems; 2. work with the structure of the product (parts, assembly units, materials, etc.), as well as with technical documentation related to the product; 3. organization of electronic archive and electronic document management; 4. providing access to a centralized structured repository of documents; 5. management of access rights to information and documents; 6. management of the life cycle and the state of documents.
7	T-Flex Technology	"TopSystems"	The stage of directive design includes a description of the technological structure of the product, the definition of the route (casing) of manufacturing with the definition of enlarged time standards for workshop transitions, material rationing with the calculation and assignment of workpieces. The prompt solution of these tasks within the framework of the Chamber of Commerce and Industry is a key factor for ensuring efficient, namely, economically viable production. The data obtained at this stage makes it possible to form a list of production needs and to assess and plan resources, which means that at an early stage to implement production and procurement planning with a high degree of accuracy.
8	TECHCARD	Firm INTERMECH	The system is designed for complex automation of the Chamber of Commerce and, in particular, design automation technological processes of mechanical processing of workpieces.
9	MAS PTP system	Bee-Pitron	The Multi-User Automated Process Design System is a system with a medium level of automation. The principal feature of the system is the implementation of interactive design of route and operational technological processes directly in the PDM-system environment SMARTEAM and, therefore, in a single information environment with designers and all other specialists whose information also used in the design of technological processes.
10	"TECHNO-PRO"	The Techno-Pro system is part of the T-FLEX integrated computer-aided design system manufactured by Russian companies TopSystems and Vector [5]	T-FLEX / Techno-Pro generates operational, route-operational and route technological cards, control cards, tooling lists, title pages and other technological documents. At many enterprises, technological maps used differ from those adopted according to GOST, therefore T-FLEX / TechnoPro provides the creation of technological documents of arbitrary forms using Microsoft Word templates.

11	Vertical	Ascon	VERTICAL is a system of computer-aided design of technological processes. System Capabilities: • Design of technological processes; • Formation of orders for the design of service stations and the creation of control programs for CNC equipment; • Technological calculations; * Produced using calculation applications, which are supplied separately; • Formation of technological documentation in accordance with the requirements of GOST RF and the standards used at the enterprise; • Support for a single information space for product lifecycle management.

In the considered systems, the following methods of TP design are implemented:
- 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 [5].

Despite many advantages, the considered systems are still poorly adapted to the design of technologies in the aviation industry and do not allow the formation of variants of technological structures with their subsequent analysis and multi-criteria optimization.

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 non-automated design processes [6].

For automated process design systems used in CALS - technologies, it is required to create new methods and techniques for systematizing process information, for example, in the form of a special design - an abstract process [7].

To develop automated systems for the formation of technological solutions, it is necessary, first of all, to find out the features of the product and the process of its manufacture as technical systems [8].

For a hierarchical representation of the design process, a complex classification and typification of technological processes developed by Professor P.F. Chudarev can be used. and developed by his students (Lukyanets Yu.F., Golovin D.L., Vlasov V.V., Komarov Yu.Yu.) [9].

In the main production of a modern enterprise of the aviation industry, regardless of the volume of production, a very large number of various technological processes are used to manufacture an aircraft. All these processes, as shown by the macrostructural analysis of the aircraft and the process of its materialization, are divided into three interrelated classes: procurement and processing, assembly and adjustment and testing [10].

In turn, the classes of processes are divided into subclasses and groups, and each group is divided into subgroups and particular processes, each of which consists of actions (mechanical, physical, chemical or combined) [11].

3 Research and results

As a result of the analytical classification, a set (array) of particular processes was determined, from which specific technological processes for manufacturing parts are made up.

This approach made it possible to make a complex classification - to determine complex classes, subclasses and groups of particular processes based on the most significant features.

With regard to the manufacturing processes of aircraft airframe parts, the main shaping processes are: cold deformation and removal of excess material, or a combination of both.

The complex classification made it possible to divide all the many parts of the airframe, the many semi-finished products and blanks, and the many processes of converting raw materials into parts into five complex classes [12].

The first complex class includes: skins, ribs, frames, stringers, rods, etc., made from a standard semi-finished product (sheets, profiles, profiled plates and thin-walled pipes). The main process of shaping parts of the first class is the process of cold deformation - bending, drawing, stretching, extrusion, etc [13].

The second complex class includes: rods, rollers, cylinders, axles, frames, ears, frames, etc., made from a standard semi-finished product - bars of various shapes in cross section and from thick-walled pipes, as well as from special blanks - inaccurate stampings and castings. The main process of their shaping is the process of removing excess material from all surfaces of the workpiece. In the manufacture of parts from a standard semi-finished product, the technological process also includes the cutting process - the division of a semi-finished product into blanks [14].

The third complex class includes: monolithic panels, sheathing, shelves and walls of shaped and variable section, made from a standard semi-finished product - sheets, flat slabs and strips.

For their shaping, both the process of removing excess material from the material and the process of deformation are used. The technological process of manufacturing a part, as a rule, includes the process of cutting a semi-finished product into blanks [15].

The fourth complex class includes: power units, frames, monolithic compartments, shelves of spars, panels, etc., made from special blanks - precision stampings, castings and pressed blanks [16].

The fifth complex class includes: diffusers, cones, socks, wingtips, etc., made from composite materials - powders, granules, plastic tablets, ceramics and cermets. The workpiece manufacturing process will essentially be the part manufacturing process [17].

The above division of complex classes into their subclasses concretizes the approach to the construction of fundamental structural diagrams of technological processes for manufacturing parts [18].

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.

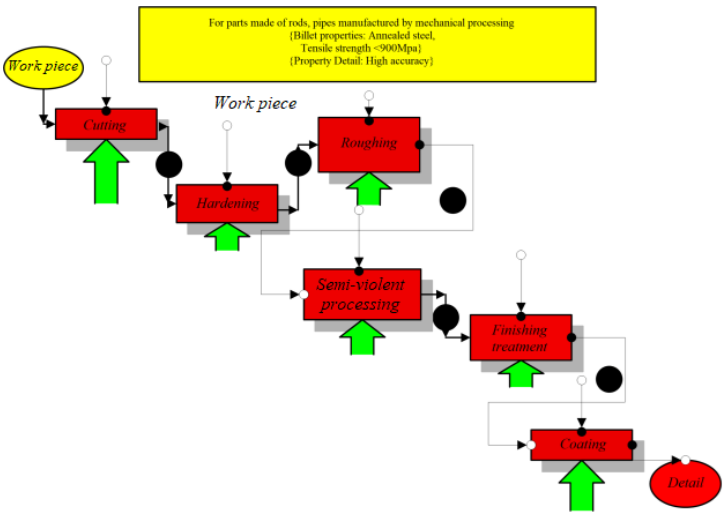

Fig. 1. An example of a structural diagram of the manufacture of parts 1st complex class

Thus, at the levels of groups of private processes, these structural schemes are invariant to specific production conditions. This property of block diagrams makes it possible to put them as initial information in the basis for the development of automated systems for designing the processes of manufacturing parts [19].

The considered systems of computer-aided design of technological processes can be classified according to GOST 25501.8-80. Most of the considered systems can be classified as medium-automated (from 25% to 50% of procedures are automated), with low productivity (up to 100,000 documents per year, on A4 format) [20].

Conclusion

Based on the results of the work done, it can be concluded that a reduction in the cost of technological preparation of production can be achieved through a hierarchical representation of the design process, which involves the use of a complex classification and typification of technological processes. The latter makes it possible to identify groups of private processes whose block diagrams are invariant with respect to production conditions, which, being the basis for the development of automated systems for designing technological processes, can significantly reduce the cost of technological preparation of production.

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