Possibilities of information technologies in the processes of designing efficient processes for the production of aircraft structures

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Abstract. The work presents the process of studying CAD- Systems and systems of technological automated design of elements of aviation structures in serial production of aviation equipment. It has been established that the most important goal of laying CAD systems is to create a single information space, which It involves the rejection of direct interaction and data transfer between all participants in the product life cycle, which is implemented in the system of automated design "Vertical".

1 Introduction

According to the concept of information technology, as the application of methods and means of computer technology in the processing, collection, storage, transmission and use of various data, modern aircraft manufacturing uses automated systems of various levels and purposes. The concepts and definitions associated with these systems are presented in the RF standard [1]. With the modern development of engineering and technology, these systems are used at all stages of the life cycle of products, including the design and production stage of the elements of aircraft structures considered in this paper. As you know, modern aviation production is characterized by the following [2]:

1. Widespread use of automated and automatic equipment - CNC machines, flexible production modules (CNC machines plus industrial robots), automated transport systems, automated warehouse systems, sections and workshops.

2. Frequent change of product range.

3. High quality of products, due to the nature of these products and the features of their operation.

4. The need for efficient use of expensive technological equipment, as well as the need for the availability of high-quality development of all technological documentation.

At the same time, the development of design and technological documentation is accelerated many times over, and the possibility of detecting errors is provided - from design to production of the product.

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The most important goal of digital technologies is the creation of a single information space (SIS), which involves the rejection of direct interaction and data transfer between all participants in the product life cycle [3]. The features of the UIS are (Fig. 1.):

- presentation of information in electronic form (convenience of storage, modification, transfer);
- coverage of all information about the product, about production, about control throughout its entire life cycle;
- it is a source of data for any participant in the product life cycle;
- integration of software and hardware, where international, national and industry standards are used;
- use of software tools available at the enterprise for the formation of the UIS.
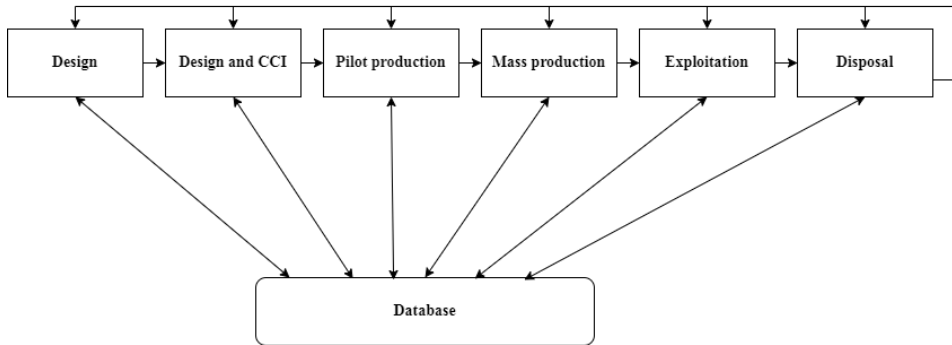
Fig. 1. Single Information Space (SIS).

The key point is the transition to the electronic identification of the product (EDI), which provides information support for the product throughout the entire life cycle. The main components of ESW [4]:

- tool complex of software for computer-aided design CAD;
- technology of automated parallel design in the mode of group data use;
- CAE engineering analysis system;
- automation system for technological preparation of production CAM, CAPP;
- PDM design and engineering data management system;
- visualization and documentation development system;
- database management systems.

The use of these technologies in the field of production allows [5,6]:

- reduce design costs - from 10 to 30%;
- reduce the time of product development - by 1.5 - 2 times;
- reduce the launch time of new products - from 25 to 75%;
- reduce the proportion of marriage from 73 to 23%;
- reduce the cost of preparing documentation - up to 40%;

Each of these systems is associated with the relevant elements of the product life cycle and implies the use of appropriate software and hardware systems. This approach makes it possible to reduce complexity, ensure the stability of the course of technological processes, the parameters of the accuracy of manufacturing and assembling the aircraft, and reduce labor intensity in general.

2 Model and method

One of the features of Russian aviation production is the construction of technologies based on route-operational technological processes. The description of technologies within the

framework of the CCI (technological preparation of production) is carried out through sets of technological maps: route (MK), operating (OK), route - operating (MOC), which describes the entire technological process [7,8].

Route operating technologies also determine the structure of production units [9].

In Russia, the development of technological documentation is carried out by the department of the chief technologist (CDP) or the technological bureau (Fig. 2) [10].
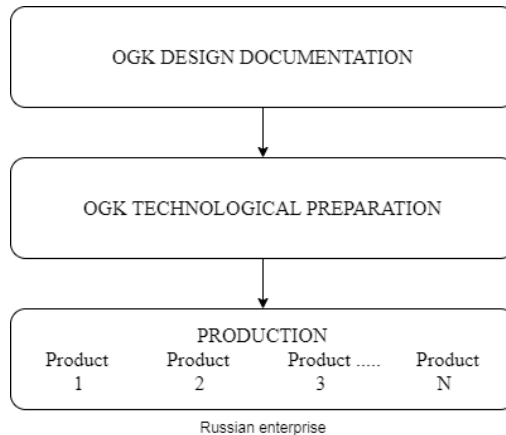
Fig. 2. The composition of the design and technological preparation of production in the Russian Federation.

Computer-aided design of technological processes is an urgent modern task in connection with the implementation of the state program of import substitution in the development of software and digital technologies based on mathematical, design, and technological foundations [2,4,9]. The technological foundations of databases, which are widely used in CAD systems, should also be added here [11].

The use of the Russian CAD TP "VERTICAL" solves most of the tasks of automating the processes of technological preparation of production (TPP), namely:

– design of technological processes for the manufacture and assembly of structures;

– calculation of material and labor costs for production;

– determination of workpiece processing modes;

– automatic formation of sets of technological documentation in accordance with GOST RF and standards used at the enterprise (STP);

– formation of orders for the design of special means of technological equipment and the creation of control programs for equipment with numerical control (CNC);

– keeping technology information up-to-date through change management processes;

– support for the process of building a single information space at the enterprise to manage the life cycle of a product from development to disposal.

To date, the following are best known on the market of CAPP-systems (CAD TP):

- ADEM TP (Moscow, Izhevsk),
- TechCard (Interfur, Minsk),
- SPRUT TP (SPRUT - Technology, Naberezhnye Chelny, Moscow),
- APPIUS (APPIUS, Moscow),
- VERTICAL (ASCON, St. Petersburg),
- T-FLEX Technology (Top Systems, Moscow).

In the aviation industry, the Russian CAD system TP "Vertical" has proven itself well (Fig. 3), the database of which includes the main industry standards [12].
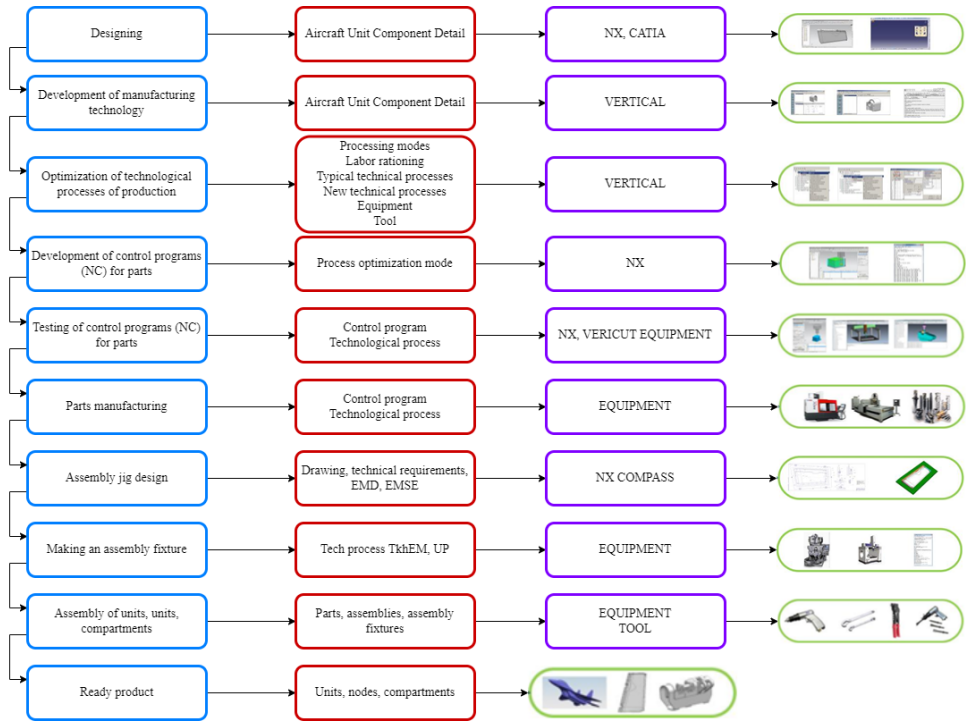
Fig. 3. CAD TP "VERTICAL" in the general structure of the design and production cycle of the product.

3 Research and results

In the VERTICAL environment, a technologist can create the following types of technological processes [13,14]:

- technological process of manufacturing the part;
- technological process of manufacturing an assembly unit;
- typical (group) technological process.

The basis of the system is the tree of structural and technological elements of the part (CTE), or simply FE (Fig. 4). KTE (or FE) are elementary geometric figures on the surfaces of a part, for each of which a processing method is selected and assigned.
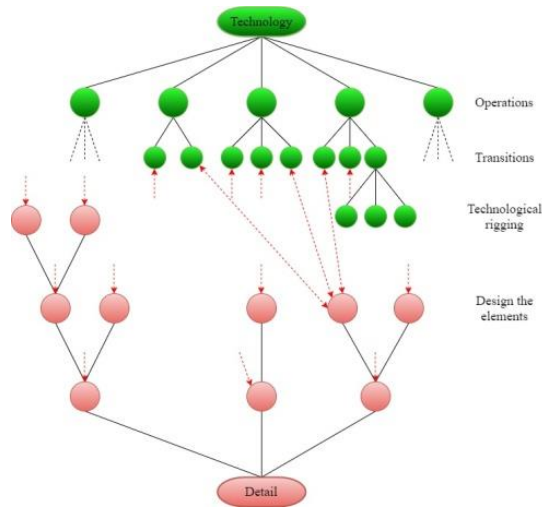
Fig. 4. Complex of technological and structural elements.

A technologist, working on a project, can send a task for designing, for example, a welding operation to a welding technologist, who, in turn, after designing, returns it to the technical process. All this can be implemented through the heads of departments, who will appoint executors with setting deadlines and design priorities. It is recommended to do this through the Pilot-Technologist application [15-17].

The relationship of CAD TP "VERTICAL" with the main applications that form a single information space (SIS) of the enterprise is shown in Fig.5.
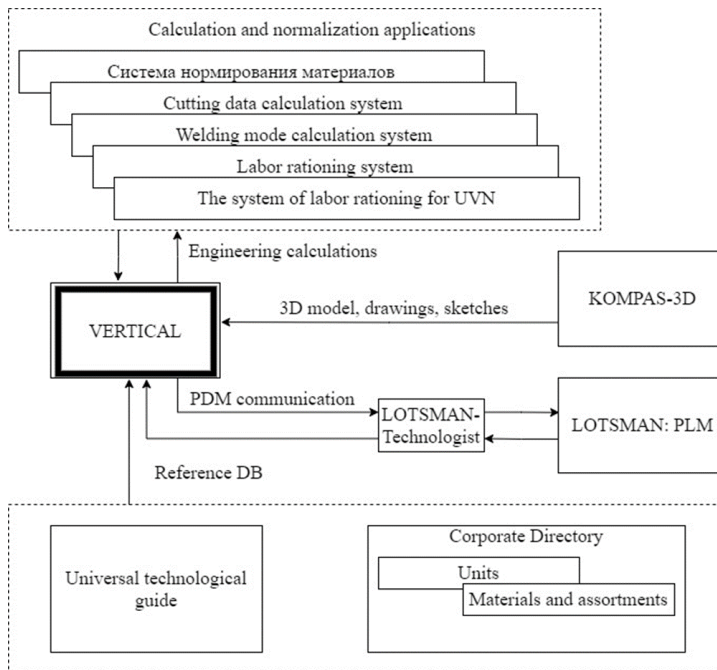

Fig. 5. Scheme of a single information space of the enterprise.

Automatic formation of technological documentation in the system is implemented through the application "Vertical - Reports".

In Russia, 3D modeling systems are most widely used: Solid Works, Inventor, and Unigraphics. The best domestic 3D modeling system is T-Flex CAD 3D. The KOMPAS-3D system competes with it in popularity. Domestic systems turned out to be better suited for the Russian user due to the interface and documentation development features in accordance with GOST.

As an example of technological design, let's consider an aircraft detail (an upper rudder mounting bracket - a milled mechanical part, Fig. 6).
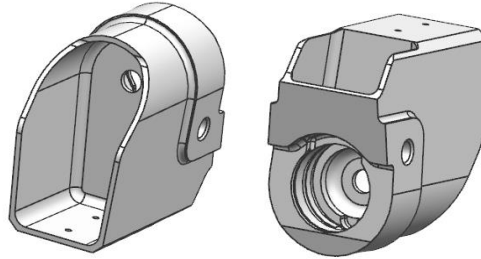

Fig. 6. 3D model of the upper rudder mounting bracket.

The contour is milled according to the program on a CNC milling machine according to the control program, according to the recommendations.

During the technological design of the bracket, an operational blank is created on the basis of its CAD model (Fig.9), which contains, in addition to geometric and design information, also geometric and technological data on the step-by-step transformations of the blank into a part.

Based on the dimensions of the bracket, a slab with a width of (65 ± 0.5) mm was selected according to GOST 17232-99 from the database of blanks.
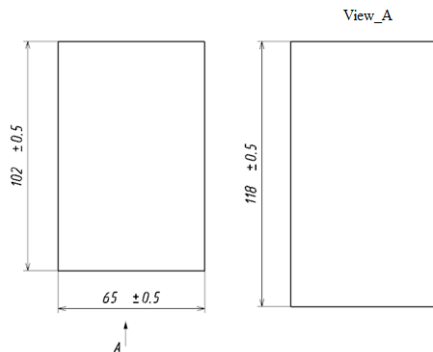
Fig. 7. Preparation of a part according to the TCB database.

When installing a part in a machine fixture, we must take as technological bases real surfaces in contact with the installation elements of the fixture.

Thus, in relation to the studied process of production of the considered typical aircraft part, we divide the basing process into 2 installations (Fig. 8, 9). On the first installation we have rough bases (still unfinished surfaces), on the second, final - finishing ones.
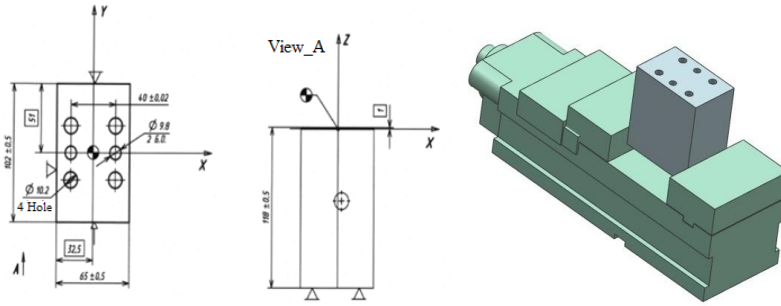
Fig. 8. Billet basing on the first installation.
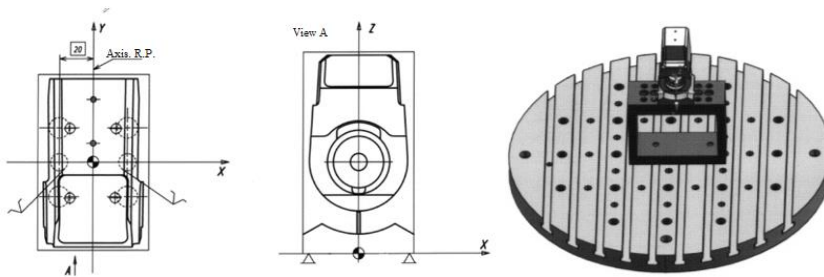
Fig. 9. Locating the part in a special fixture on the second (final) installation.

Types and brands of machine tools are selected using the corporate database "Vertical" for machine tools. The choice of cutting tool is carried out according to the type of technological operation (turning, milling, reaming), the dimensions of the machined surface, the properties of the material being machined, the accuracy of processing and the required surface roughness, the brand of structural material, the type and serial production and other parameters.

Based on the above, taking into account the serial nature of the production of the aircraft part considered in the example, technological equipment and cutting tools were selected (Table 1):

Table 1. Equipment and cutting tools.

№ p/p	Transition name	Name and designation of the cutting tool	Cutting tool brand	Note
1	Horizontal milling machine 6R82G	Cutter ⌀250 GOST 2679-73	R18	Mandrel 6225-0176 GOST 15068-75
2	Vertical milling machine FP-17	Cutter ⌀40, No. 243678054	R18	Mandrel 6269/0063
3	Machining center DMU-60	Cutter terminal ⌀32 , R4 MT190-032Z32R03AD10-L150-IK-AL		Cartridge Weldon
		Plate L_{dir} =10 ADKT10N340FR-AL		Cutter terminal MT190-AD10
		Centering ⌀2,5; <118^0 QCT DMGC-CD-A-020500		Collet chuck
		Drill ⌀10,2; <118^0		Collet chuck

		GOST 10902-77		
		Drill ⌀9,8; <118^0 GOST 10902-77		Collet chuck
		Drill ⌀3.0; <118^0 №278609515 GOST 10902-77		Collet chuck
		Drill ⌀10.0; <118^0 GOST 10902-77		Collet chuck
		Cutter terminal ⌀16, R4, Z2 FCC 07970 16x24x100x16		Collet chuck
		Cutter terminal ⌀16, R2,5, Z2 FCC 07980 16x24x100x16		Collet chuck
		Cutter terminal ⌀16, R5, Z2 FCC 0798016x24x100x16		Collet chuck
		Cutter fungal ⌀35, R0,1 8909.67854.78		Collet chuck
		Cutter fungal ⌀35, R0,8 98678.678.0976.09		Collet chuck
		Cutter terminal ⌀8, R0,8 987.8907.786.73		Collet chuck
		Cutter terminal ⌀8, R4 FC 98657 8x15x80x8		Collet chuck
		Cutter terminal ⌀5, R1,6, Z2 FC 9867 5x15x51x5		Collet chuck
		Boring cutter ⌀37, R0, Z2 № 236023890		Collet chuck
		Пластины F101 02GN112 WHT32 297098485		Boring cutter
		Cutter terminal ⌀12, R4, Z2 FC 78567 12x18x100x12		Collet chuck
		Cutter terminal ⌀12, R2,5, Z2 FC 8979 12x18x100x12		Collet chuck
4	Vertical drilling Machine 2H135	Scan ⌀9H8, d$_H$ =3 № 8976.675.908.03	R18F2	
		Countersink ⌀20, d$_H$ =9, <90^0 № 67878.8976.980.04	R18	

The greatest effect when using high-level systems can be achieved using a complex of computer-aided design systems (design CAD systems) and process design systems (CAD TP). This principle is used in this example. The KOMPAS-3D program was used as a CAD system, and VERTICAL was used as a CAD system.

The design of the technological process was carried out by the method of forming a TP tree. The choice of equipment for TP operations, cutting tools, calculation of bracket surface treatment modes, time standards for part manufacturing was carried out using the appropriate databases of the Vertical system, TCB tabs and built-in algorithms. As a result, a technological process was formed, the route component of which is given in Table 2.

Table 2. Route technological process.

Operations	Equipment	Types of processing
005 Control		
010 Cutting	Vertical milling machine FP-17	Milling
015 Locksmith	Pneumatic machine PMZ-31-250	
020 Markup		

025 Horizontal milling	Horizontally - milling machine 6R82G	Milling
030 Locksmith	Pneumatic machine PMZ-31-250	
035 Marking		
040 Markup		
045 Vertical - milling	Vertical milling machine FP-17	Milling
050 Markup		
055 Vertical - milling	Vertical - milling. machine FP-17	Milling
060 Markup		
065 Vertical - milling	Vertical milling machine FP-17	Milling
070 Vertical - milling	Vertical milling machine FP-17	Milling
075 Locksmith	Pneumatic machine PMZ-31-250	
080 CNC milling	Machining center DMU-60	Milling
085 Locksmith	Pneumatic machine PMZ-31-250	
090 CNC milling	Machining center DMU-60	Milling
095 Locksmith	Pneumatic machine PMZ-31-250	
100 Vertical - drilling	Vertical - drilling machine 2H135	Drilling ⌀8.7 Chamfer (1±0.30) mm 450
105 Control		
110 Coating	Galvanic baths	An. ox. xp.(oxide electrical insulating filling in a chromate solution
115 Coloring		Enamel EP-140
120 Control		

For a more visual representation of the dimensions performed on a particular operation, the quality of surfaces, spatial deviations, the location of the part, etc., a ready-made or a new technological sketch can be connected to each TP operation. For the formation of working technological documentation, transferred directly to the working areas, the "Map Maker" function was used. The wizard for generating technological documentation determines the required type of technological document, according to the settings assigned by the technologist.

One of the main components of the system is the possibility of calculating processing modes and carrying out labor rationing of technological operations (Fig. 15). This allows you to select the optimal technology option according to the criteria of labor intensity and cost.

Access to the application "Universal system of labor rationing according to the enlarged general machine-building time standards" is carried out through the context menu of the Labor rationing tab of the TP tree. The tab also contains a list of cards used to carry out the normalization of the operation. This list of maps is formed by the user during the calculation of rates. A fragment of the technical process can be connected to each normalization map for subsequent use by the technologist when designing the TP.

The application provides for the possibility of developing and connecting user cards for labor rationing, tables of correction factors, adjusting formulas that determine the results of calculating part-time work.

4 Conclusion

Thus, in this paper, we consider the main provisions of automated design of technological processes in CAD TP "VERTICAL" associated with the design and technological features of typical parts of modern aircraft, the use of CAD systems for designing elements of aircraft structures, their interaction through the procedure for importing parameters from one system to another. Also considered are the economic aspects of carrying out certain stages of technological preparation for the production of typical representatives of aircraft structures through the use of appropriate software applications and their interaction with design and technological complexes. On this basis, databases of design and technological preparation of production of a single information space of the enterprise are formed.

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