UDC 004.896 (075.8)
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THE PRINCIPLES OF HYBRID COMPUTER-AIDED DESIGN SYSTEM OF TECHNOLOGICAL MACHINE

It is developed the hybrid system of automated designing of technological machine layout that combines traditional CAD of optimization synthesis of technological operation structure and optimization synthesis of machine structure and an expert system. The interaction between all components of the hybrid CAD is implemented using the system of production rules located in the knowledge base of the attached expert system. It is represented the structure description of the hybrid CAD and principles of the software implementation of layout automated designing.

Layout; structure; designing; CAD; structural optimization; conceptual modeling; knowledge base; expert systems.

1. The problem statement

Currently, the automation development of the designing processes, including technological machines, does not lead to the received results that can bring this process to a new high-quality level. In modern CAD only certain procedures are computerized. Problems arising at the early stages of the technological machines designing: the formation of the technical task, the development of technical proposal and schematic and technical designing, drafting the working documents solved interactively by the design engineer. These procedures are associated with the solution of weakly structured tasks that are hard formalized, so hard subjected automation within the existing automated design methodology. But, "the cost of failure" by designer was grown with the complexity increasing of technological equipment designing, especially at the early stages. The low efficiency of traditional CAD at the early stages of the designing was the stimulus for the creation of CAD, automating the most responsible early stages of development [1, 2, 3].

One method of successfully solved problems is creating of a hybrid computer-aided design (HCAD) that combine the traditional CAD systems that are based on algorithmic data processing and the expert systems (ES), working with knowledge base and allow to make appropriate decisions in many intermediate and final design stages [4, 5]. Scientists of Center for Artificial Intelligence Cranfield University (England) define "hybrid integrated system" as a system that uses more than one computer technology. Integration of technologies makes it possible to use individual power of technology for the solving specific parts of the task. The technology selection introduced in the hybrid system depends on the features of solved problem. The HCAD for solving complex problems can be treated as a system of methods for solving subproblems of a complex task. The essence of hybrid approach is that the means are implemented in the usual interactive designing system and these means extract the knowledge accumulated in the information database (DB) and using it to design in cases when the basic algorithms cannot cope [5, 6].

The constant progress of information technology on the one hand, and the constant modifications and increasing the complexity of projected technological machines, on the other hand, leading to the need to consider the CAD as a system, which should provide with the help of designers the ability to add new features and components in the designed object. Now the problem of increasing the degree of automation and complexity of the design process are solved using artificial intelligence technologies. This approach has allowed to create a new class of software -- hybrid CAD (HCAD) [6, 7]. Designing is the ability of programs created with the use of expert systems (ES), to store the knowledge (in this case, the designer knowledge), to carry out the work and make decisions. Structural CAD components that effectively improve the quality of the designing process can become the expert systems (ES) [5], which relate to systems based on knowledge, and form with projected subsystems the intelligent information systems – the hybrid CAD.

This technology enables developers of automated data processing systems to use in the designing the device of system analysis and conceptual modeling for understanding and reducing the complexity of practical tasks, as well as original methods, models, algorithms and programs that synthesize the hybrid to solve the problem.

System analysis methods include:

- the development of a common scheme of problem solving;
- the decomposition of complex objects and processes of its development;
- the methods of goals formation, selection and coordination of criteria;
- the principles of preparation and reasoning of decisions, including informal procedures.

Decomposition and aggregation operations correspond in the investigation and development of complex systems, including technological machines and systems of computer-aided design, analysis phases and synthesis. Decomposition (division the whole into parts) and aggregation (combining of disparate elements into one) - basic operations of system analysis used in all procedures of designing. So the following general order for solving the problem of designing can be offered:

- the separation of general task into parts (local tasks);
- the decision to each of the local tasks;
- the decisions integration of local tasks;
- the coordination of local decisions from the positions of the general task.

The importance of the last phase of the decision process - coordination of local solutions from the wide systematic positions should be emphasized. The practice of designing contains many examples, in which each components of a complex object performs its functions quite effectively, and the whole system is clearly far from the best option. Purposeful activity of designing is characterized by the purpose, object, methods and criteria of goals achievement. All these components must undergo the separation into simpler parts in decomposition. Accordingly, the following principles of decomposition are used in the development of such complex systems as technological machines:

Criterion-based decomposition - determining the main goal of technological machine (product production with given quality characteristics with a given productivity under the given constraints), its decomposition into local goals and subgoals; formation of criteria – evaluation system of achieving goals (achieving optimal value of the product cost, machine cost, its energy consumption, versatility, compactness, etc.).

Functional decomposition - determination of functional tasks, subtasks, certain procedures and operations for technological machines, functional decomposition is reduced to determining the structure of technological operations.

Structural decomposition - determination of subsystems and elements that provide the fulfillment of certain system functions for technological machines – a set of aggregates that perform a technological operation.

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2. The structure of the hybrid CAD

Structural CAD components that effectively improve the quality of the designing process can become the expert systems (ES) [8], which relate to systems based on knowledge, and form with projected subsystems the intelligent information systems – the hybrid CAD (Fig.1).

The main advantage of the hybrid computer-aided design (HCAD) – the possibility of knowledge accumulation and saving them for a long time. The purpose of the HCAD – a knowledge concentration of experts in a specific applied area − technological machines, simplifying of decision-making procedure by users, improving the quality and efficiency of design works [9]. An expert in technological machines (task producer) and a specialist in system filling (knowledge engineer) are necessary to generate constraints in the suitable form for using in HCAD. As a result, users of CAD, which has a structure of the ES, will have an information support based on the knowledge and

experience of qualified professionals about the designed object. Such interaction of designed algorithms with ES allows automating those procedures of designing process that are solved on the basis of designer knowledge and cannot be represented in the form of algorithms.

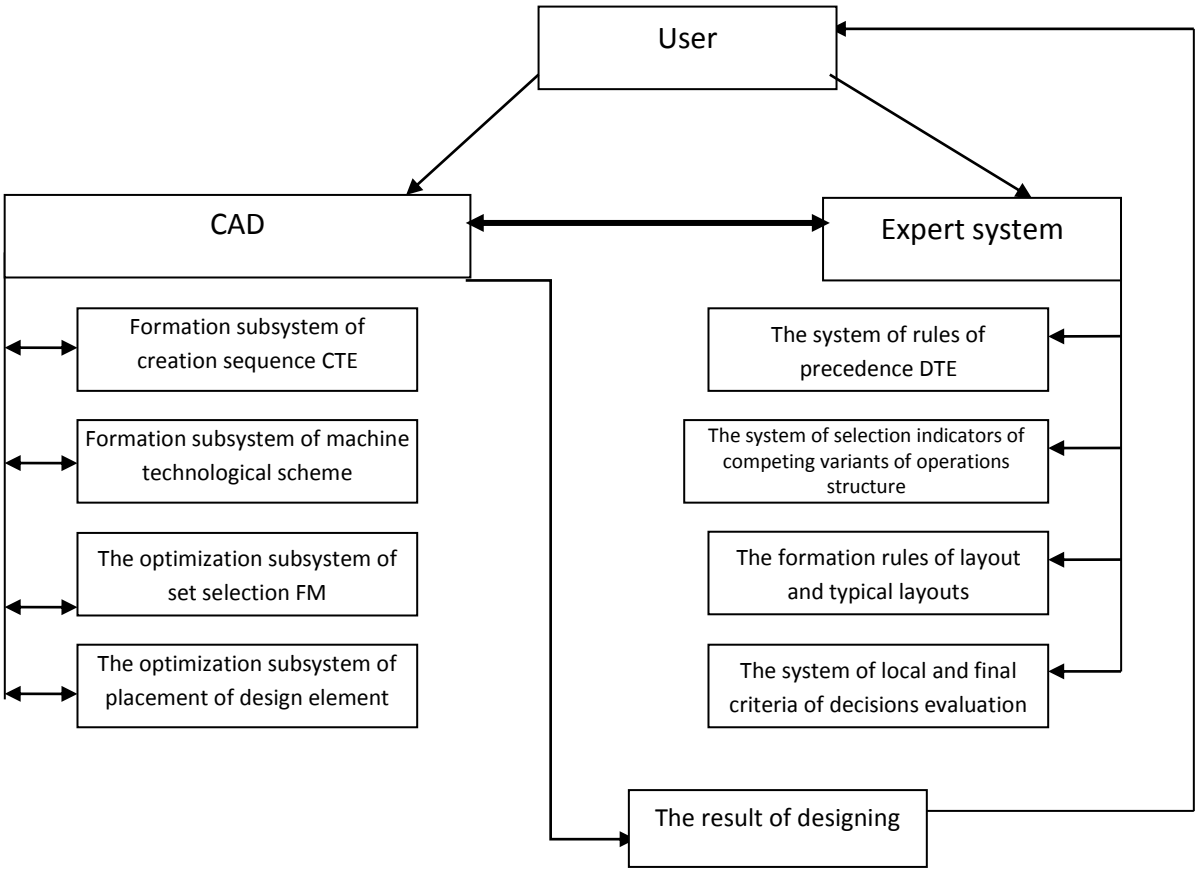

Fig.1. The structural scheme of the hybrid CAD for designing layouts of technological machines

According to Fig. 1, we can conclude that HCAD – software package consisting of a plurality of created from each other program blocks, and sometimes those that are independent from each other. It includes the modules that are based on algorithms and programs that operate on the basis of logical reasoning and knowledge about the technological equipment.

2.1. Traditional Cad as the components of HCAD

Structural components of the CAD are subsystems that have all system features and are established as independent systems. It is marked by certain features the parts of CAD that provide the implementation of the completed design tasks with receiving the relevant design decisions and design documents.

By an appointment the CAD subsystems are divided into two types: **designing** and **servicing**. Each CAD subsystem gives completed design solutions. The division into subsystems is associated with the dismemberment of ideas about technological machines as multilevel designing objects according to their block-hierarchical structure. These levels generate the subsystems, called designing subsystems. Designing operations and procedures of one or more related levels are carried out in each designing subsystem.

The designing process is implemented in the subsystems in the form of a certain sequence of design procedures and operations. Designing procedure corresponds to the part of designing subsystem, as a result of which some design decision is accepted. It consists of basic designing operations, has firmly established order of their implementation and aims to achieve local objective in the designing process. The designing operation is relatively isolated part of designing procedure or elementary action undertaken by the designer in the designing process. Examples of designing procedures are kinematic or layout scheme of a machine, product processing technology, etc., and

examples of designing operations — calculation of modes, the problem solving of semi-finished product form and etc.

The CAD subsystems of technological machines layouts that perform the relevant design procedures and operations are related to the ***designing*** subsystems:

- the subsystem of functional designing of product formation sequence and structure formation of technological operation;
- the designing subsystem of machine technological scheme;
- the subsystem of the optimal set selection of functional modules and designing of machine layout;
- the optimization subsystem of placement FM in the machine working area.

The CAD subsystems assigned to maintain efficiency of designing subsystems are related to the ***servicing***:

- the subsystem of design objects graphical representation;
- the subsystem of documentation;
- the subsystems of design data management;
- the database management system (DBMS);
- the subsystem of information searching etc.

2.2. Expert system as a part of the HCAD

Expert systems − applied systems of artificial intelligence in which the knowledge base is a formalized empirical knowledge of highly qualified specialists (experts) with a narrow subject area – technological machines. Expert systems are designed to change the experts in solving problems because of insufficient number or insufficient efficiency in solving the problem [8]. Expert systems are usually considered in terms of their using in two aspects: for solving of which tasks they may be used and in what field of activity. These two aspects influence on the architecture of an expert system that is developed.

ES is entirely independent software module and consists of, according to Fig. 2, Knowledge Base (KB), device of logical output and user interface.

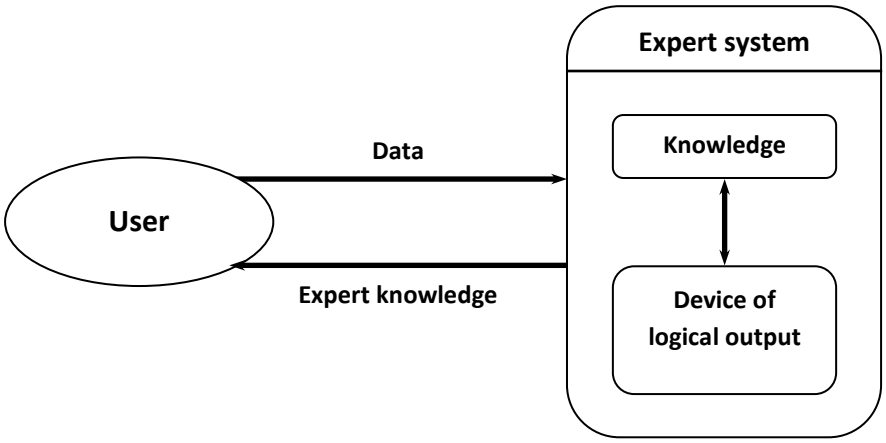

Fig.2. Structural diagram of ES as a part of HCAD

Knowledge base. The main intellectual component of the hybrid CAD is a knowledge base, in which the results of theoretical investigations and practical knowledge of experts are represented [9]. Any knowledge base consists of a database of any type (base of facts) base of rules of their using and database of procedures. Knowledge Base − an important component of an expert system, it is designed for long-term storage of data that describe this area of technological machines and design rules that describe appropriate data transformation of this area. A narrow area of technological machines, such as technological machines for packing of bulk products is selected as applied. Then the facts and rules of packaged machines designing that are placed in the knowledge base within the output mechanisms and simplifications are gathered for creation of ES in a selected area. The knowledge base can be modified and supplemented. There are several methods of knowledge representation in the ES, but represented knowledge is in symbolic form (texts, lists and other symbolic structures).

Unlike the traditional CAD, the basis of intelligent system of HCAD designing is not a system of geometric modeling but a knowledge bank, which includes:

- a metamodel of technological machine as AND-OR-GRAPH describing the known design alternatives at all levels of object decomposition;
- a knowledge base containing the rules of structural analysis of a product and structure synthesis of technological operation and technological machine;
- a databases containing referenced data about the technological machine and its functional modules.

Database of ES (working memory) is used to store the initial and intermediate data in the current time of a solved problem.

The mechanism of logical output. The basis of the ES is a subsystem of logical output [13], which uses information from the knowledge base (KB), generates recommendations for decision of a solved problem. Productions systems and the semantic networks are used for the knowledge representation in ES. The KB consists of facts and rules of type (if <premise> then <conclusion>). If the ES determines that the premise is correct, then the rule is considered as appropriate for this decision and it is set in motion. The aim of the ES - to output a given fact, called the target statement or to refute this fact. The system work is a sequence of steps, on each of which some rule is selected from the base that applies in the current content of the working set. The cycle is ended when the target statement is outputted or refuted. Otherwise the cycle of an expert system work known as a logical output.

Expert systems can be created by using ready-made "shells" of the system. The advantage of shells is that they do not require the work of programmers for creating of a finished expert system. Only experts in the applied area to fill the knowledge base are necessary.

3. The modeling of a subject area

The modeling of a subject area is the main and the first stage in designing of HCAD. Subject area reflects the composition of interacting objects. The object is a subject or phenomenon. The object has a clear behavior, state and individuality.

Object-oriented structure is described by terms of objects and their connections. The basic concepts for the structure are the object and the class.

Each object must:

- have a unique identifier;
- have a name;
- have a description;
- have a type;
- have a value;
- have limitations for values;
- have one or any number of characteristics. Characteristics must belong to the object or be inherited through the communication.

The object can be located at a certain level in the hierarchy, can have any number of connections with other model objects.

There are several local problems related with each other in working conditions of the complex system of designing:

1. the problem of modeling and analysis of the product structure to determine the sequence of its formation;
2. the problem of optimization synthesis of technological operation structure and formation of machine technological structure;
3. the problem of optimization synthesis of technology machine layout.

For each of these problems it is necessary to determine the subject area and to build the models of connections between objects of different areas. It allows to solve local problems between each other. Transforming of descriptions is used when known initial description of the structure corresponding to a certain hierarchical level, and it is necessary to get the resulting description corresponding to a different level. Algorithms of transformation use the transformation rules of elements of the initial structures in new forms. Examples: - synthesis of technological operation (the structure of technological operation with a given sequence of transitions is built describing the sequence of formation of CTE product), the flowsheet of a machine (the flowsheet of a machine is

built describing technological); the synthesis of machine layout (the layout of a machine is built describing the technological scheme) and others.

The rules of transformation have a type of products «IF A TO B». The same form can give to the rules generation of structures and in other approaches to synthesis. So most famous intellectual CAD use the productive idea of procedural knowledge part about the subject area.

Thus, in the modeling of a subject area of HCAD we should select:

1. the subject area of a product that is given by conceptual product model;
2. the subject area of a technological operation structure;
3. the subject area of a technological machine structure.

Subject area of a product. Methodology of details description and assembly units in existing CAD is the main obstacle to the creation of complex HCAD. The product models in modern systems are geometric, while the conceptual models are not necessary for automation the designing of technological processes and machines. Conceptual model of a detail is based on the notion of design and technology element (DTE) (which later became the name *features*). Such element is a designed element in the sense that it performs a constructive function in a detail, such as: provides the basing of a detail in the assembly unit (cylindrical and tapered axial holes, grooves veneer, etc.), or connects the detail with the adjacent (carvings, toothed crowns, etc.). However DTE has one or more technological transitions of its manufacturing generated from a set of transitions. DTE have a hierarchical structure consisting of DTE complex levels, basic and additional. The axisymmetrical, prismatic elements and holes are complex levels. Such set is determined by the main operation types of machining processing of details: turning, milling and drilling and boring operations. Additional elements (grooves, slots, bevels, etc.) are related to the basic, and you can start to the processing only after the previous formation of basic elements. Each DTE is an object with its own set of features.

For example, we will consider how the process structuring of machining processing of details is carried out. For a formal definition of creation sequence DTE detail, we introduce the concept of binary relation of precedence π. We consider any given technological transition. In general, we can assume that the conditions for its realization will depend from some previous transitions, on which database are created or linked surface is pre-processed or instrument access is provided. The functional, technological and designing limitations affect on the sequence of product creation and formation of its product quality parameters. There are three groups of precedence relation [2]:

- *functional relations of precedence*, that are imposed by the conditions of product functioning;
- *designing relations of precedence*, that are imposed by the conditions of spatial arrangement of details and some parts of surfaces in product design;
- *technological relations of precedence*, that are imposed by the conditions of product manufacturing.

These limitations define the cause and effect relations of designed elements of a product that are defined by the relations of precedence, lettered « π »**.** The correctness of determining the order of formation of designed elements determines the excellence of built designing and technological scheme of production. DTE of a product will be a set *E = (e1, y2, ...).* These limitations define the cause and effect relations of designed elements of a product that are defined by the relations of precedence, lettered « π »**.** The correctness of determining the order of formation of designed elements determines the excellence of built designing and technological scheme of production. DTE of a product will be a set *E = (e1, y2, ...).*

Let's consider the cause and effect relations of precedence of designed elements of a product in the form of graph Gπ or matrix Mπ. The matrix of precedence is built in the following way. At the intersection of the i-th column and j-th row we put the one and if the i-th designed element precedes j-th or zero-otherwise. Matrix of the cause and effect relations looks like:

$M\pi(e) = |E \times E| =$

	e_{11}	e_{12}	...	e_{ij}	...	e_{nm}
e_{11}						
...	1					
e_{ij}	1	1			1	
...		1	1			
e_{nm}						

Each element of the matrix satisfies the following requirements:

$$dij = \begin{cases} 1 - \text{if the } i\text{-th designed element must be created before the } j\text{-th;} \\ 0 - \text{otherwise.} \end{cases}$$

The relation of precedence is set in the ES in the analysis of the product model through a system of production rules such as "**if** DTE $_{i1}$ has certain characteristics of relations with DTE $_{i2}$, then DTE $_{i1}$ is made before DTE $_{i2}$».

Similarly, the DTE can be analyzed than the details for machining processing of products, for example a bag for packing of bulk products (Fig. 3).

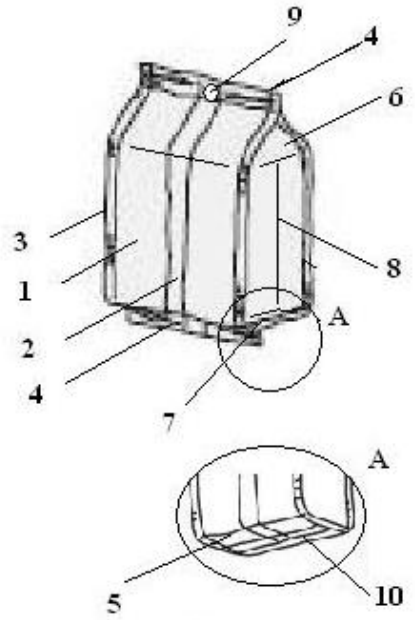

Fig. 3 Typical design and technology elements (DTE) of packages for the bulk products:
1 – casing, 2 – longitudinal seam, 3 – lateral commissure, 4 – transverse seams, 5 – bottom, 6 – the upper fold, 7– the lower fold, 8 – lateral folds, 9 – the hole for hanging, 10 – curved lower fold

The subject area of technological operation. Transformation of a product description in the description of technological operation is carried out on the following considerations. As DTE of a product are implemented by the appropriate technological transitions, the cause and effect relations between these elements determine the relation of precedence between technological transitions (Figure 4). Then the expression $F_i \; \pi \; F_j$, where $F_i, F_j \subset TO$, is read as «technological transition *Fi* precedes the technological transition *Fj*, where both transitions are parts of a technological operation».

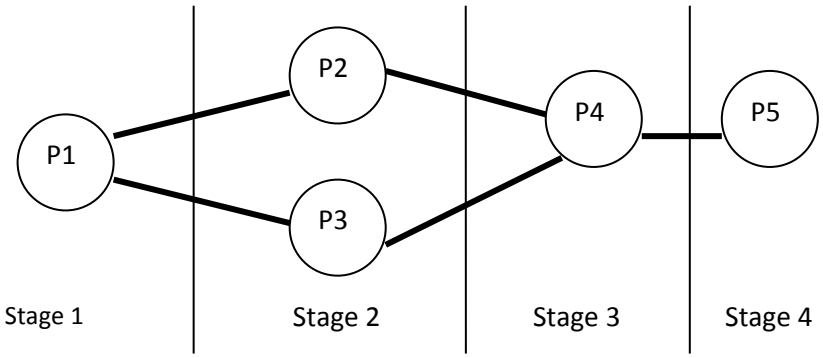

Fig.4. The sample of the technological operation structure

The example of technological operation provides two variants of its structure P1-P2-P3-P4-P5 and P1-P3-P2-P4-P5. To build the flowsheet of a machine the user can select one of them, or explore both variants at further stages of designing.

The subject area of technological machine.

Transformation of description of technological operation in the description of the flowsheet provides the introduction of each technological transition according to specific type of technical means for its implementation, such as the type of functional module. Further description transformation of the flowsheet in the layout description is made in clarifying the functional modules by its designed analogues. The building of layout model provides the optimization search of the best set variants of modules based on specified criteria optimization (the lowest price, energy consumption, etc.), which is implemented using algorithms of CAD subsystem. Let's consider as an example the subject area of technological machines for packing of bulk products. The hierarchical structure of the machine is convenient to introduce as a net model (Fig.5).

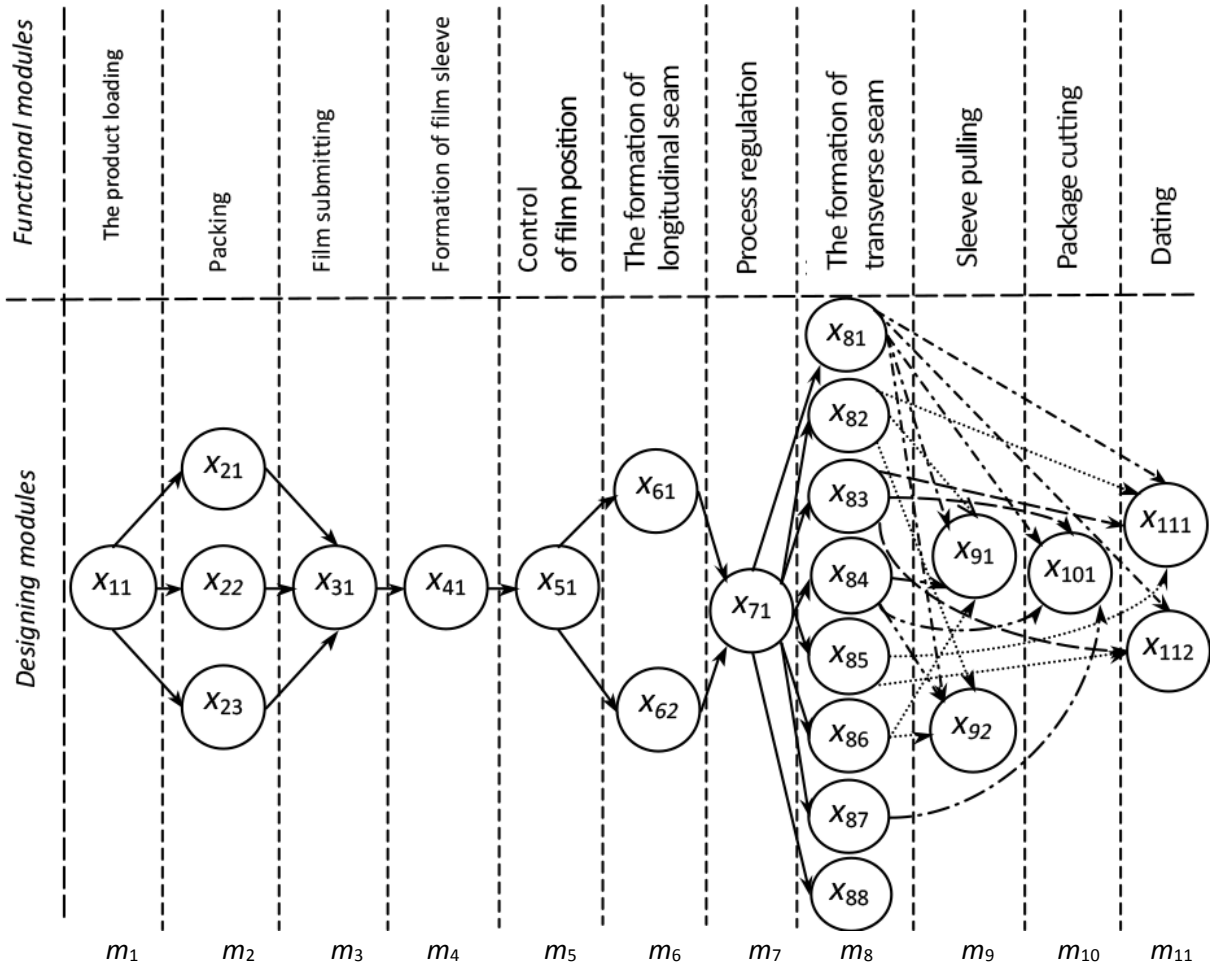

Fig. 5 Graph of logical relations between functional and designed modules of a machine for packing of bulk products

The main feature of structural synthesis is an ambiguity. The replacement of functional components (modules) for structural elements (modules) is carried out in the formation of an object structure. The correspondence between the functional and structural modules is also ambiguous – one and the same function can be realized by various structural elements. This model reflects the functional and modular machine structure for packing of bulk substances, and the possibility of combining of different designed modules between each other. The traditional method of structural synthesis involves generating of new variants for the system structure by the combinatorial methods − by replacing its functional elements of various structural elements of similar destination (Fig.6).

The selection of functional elements (modules) to implement each of the selected partial functions in the formation of the functional structure of the object, and during the formation of the

layout – the description of the transformation from the FM on the description from design modules (marked **Xnk**).

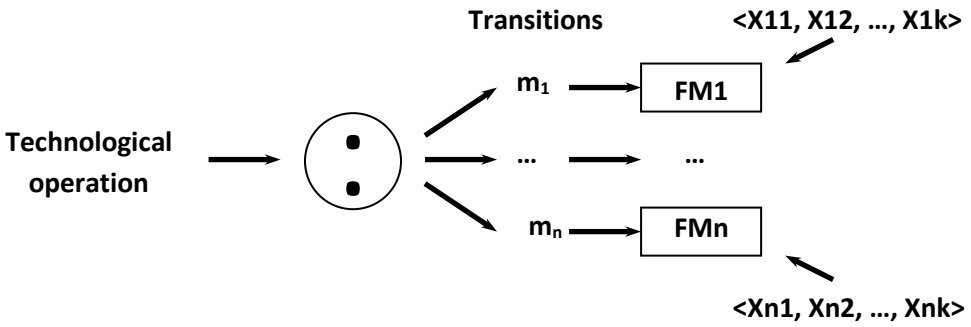

Fig.6. Optimization synthesis of a machine structure

However, generating of a new combination of design modules does not guarantee the quality of the whole technological machine. The practical value of the project decision for the structure of the object is determined mainly by solving the problem of parametric synthesis.

4. The functioning of HCAD

The task of designing is to form the structure of technological machine that meets the requirements of the TP, ie to create technological schemes of machines, identifying types of design modules for its implementation, division of function and technological transitions between them so that the extremum of objective function was achieved, which is determined by the efficiency indicators of the machine working under the given constraints in terms of its work.

The scheme of functioning of the hybrid CAD has the following sequence. First the initial data are entered: a product design, technical conditions, the requirements for technological machine (TP) and the conditions of its exploitation. The entered information is used by a system to build a conceptual model of the product, its analysis and determining the sequence of creation DTE product. Then the automated designing of technological operation structure and the flowsheet of a machine is carried out. If the user is satisfied with the result, he approves the designed technological scheme and enters it in the database. The described part is a generated branch in the diagram of the system for the designing of layout of technological machine.

To convert the data of the subject area of technological machine in methods of its designing the HCAD must provide the ability to process special knowledge, represented in algorithmic (procedural) and in expert (productive) form. The procedure for removing technical solutions in the designing includes the following steps.

1. The entering of initial knowledge and data about the type of product that can be produced on a designed technological machine and its construction of a conceptual model.
2. The construction of matrix of precedence based on the use of production rules of precedence. The sequencing of the formation of DTE product selected on the basis of computational algorithm of processing the matrix of precedence that is included in the CAD.
3. The formation of structure of technological operations using production rules and computational algorithms and forming of the flowsheet of a machine from the functional modules. If there are several technological schemes, then one or two schemes for further work are selected on the basis of production rules of a knowledge base or designer decision.
4. Optimization of a set of design modules for implementing of technological scheme based on selected criteria with one of optimization algorithms that is a part of the CAD.
5. Formation and comparing the effectiveness of alternative configurations of technological machine.

HCAD essentially combines the benefits of designing based on the synthesis of object-based model of designing and on the experience by modifying an existing object prototype. In these cases, the formation of variants of an object structure is possible using two schemes:

1. the composed scheme of designing;
2. the variant scheme of designing.

The composed scheme of designing provides the object composing, ie the synthesis of the elements of its structure by given rules. Structural synthesis is the most difficult design procedure for formalizing. In existing CAD in most cases synthesis is performed by a human and computer is used for verification of the proposed variants. The level of design automation degree is defined primarily by the state in algorithmization of procedures of a structural synthesis. There are different approaches to problems algorithmization of structural synthesis.

In the synthesis algorithms there are blocks of formation of the next variant of its evaluation and decision-making. The selection of completed structures is used when rating of intermediate variant is complex, so the completed structures of objects should be created in a unit of formation as, for example, it can be made for the layout of the technological machine. The set capacity of possible variants can be so large that the whole selection is impractical. In such cases, the selection may be only partial, based on approximate (heuristic) algorithms. Example is a discrete mathematical programming problem, in particular, the problem of minimizing the cost of technical means or maximizing of productivity and etc.

Another variant of implementation of structural synthesis is carried out by increasing of a structure adding design modules to some of the primary structure with the rating of intermediate variants of the structure. Generation of variants in this case is directed, and the first variant that was generated often becomes final. Therefore, algorithms of increasing are faster compared with surmountable, but less accurate.

The selection of a variant from the generalized structure also generates the sequential algorithms. The generalized structures that describe the class of designed objects usually are presented in the form of AND-OR-graphs. Algorithmic synthesis based on AND-OR-graph requires the inputting of selection rules of alternatives in each OR-top. The difficulty in this case is related to possible restrictions on the compatibility of methods to implement features: $C_{ij} + C_{kl}$ = false, which means a prohibition on the simultaneous inclusion of elements E_{ij} i E_{kl} in the structure of system.

If you have any problems during the designing of technological machine through its layout of elements on the given rules, the variant scheme of designing starts to work.

The variant scheme of designing is realized by selecting from a library the standard solutions of a given structure and its partial modification to adapt to new conditions of using. The system performs the searching of similar cases in the database. The algorithms of searching are based on a comparison of characteristic parameters of the initial and current technology solutions in the database. Indicators of technical task are used as parameters

Thus, the hybrid CAD can be considered as an interactive system that implements generally two schemes of designing.

The main difference between HCAD technological machines is the presence of two interrelated design objects – the structure of technological operation and the structure of the technological machine. The transition from one structure to another is carried out by means of intermediate technological scheme of the machine in which elements of the structure of technological operation are located in the working area of technological machine. Then the results of the designing are presented in the 3D form – models and working documents created on its basis. Therefore, the design process becomes the three-phase process.

In **the first stage**, which can be called a generation scheme or design-based model, the designing is carried out on the basis of algorithms. The input source of information for the first stage is the product information in the form of a conceptual model. The resulting output document is the structure of technological operation (possible in several variants) with a list of technological transitions and also a flowsheet of machine. The first stage of designing ideally works automatically. There is possible a dialogue with the user in advance predefined algorithms when the solving of several problems at the first stage is impossible and meaningful. The first stage is ended by receiving of acceptable project documentation in the form of the map of technological operation and a flowsheet of machine in the algorithms of the system functioning that worked fairly well, and the functional designing can be regarded as complete.

In **the second stage** of designing user analyzes the resulting of technological scheme of the machine and, if necessary, corrects it. After that the layout designing of the machine is carried out, which is in two versions: in the mode of combinatorial generation of variants of machine layout based on the model of its structure or in automatic searching for solutions, using previously accumulated in

the database information. The variant scheme is realized, which is based on the available information in a database about all designed machines selects the suitable variant for the characteristic parameters.

In **the third stage** of designing the geometric models of design objects are formed: details, design modules and a machine layout in general. For this HCAD includes the systems of geometric modeling, referred as modelers or "geometric cores" of CAD. An integral part of such systems is the presence of a graphical interface that allows you to display the received design results. In addition, the use of three-dimensional modeling systems is a necessary condition in the designing of technological machine, since the 3D model is often a requirement of technical problem. The designer and the customer can simply define the geometric consistency of a model, form the basic drawings, and form the requirements for calculations and related tasks using the created virtual model of technological machine. Such model allows us to form specifications of functional and design modules, products and materials used in this model.

The part of graphical interface is a system of electronic image catalogs which is designed to select functional and design modules to be placed in the working area of designed technological machine. These catalogs allow you to get information about the functional and design modules, such as the type, size, weight, cost, design features, the size of nozzles, connecting spaces and holes. Working with the electronic image catalogs, the user has the ability to learn the graphic examples of functional and design modules. The using of 3D-modeling allows to improve the quality of designing, to evaluate the situation at previous-designing, to increase the competitiveness of designed samples.

Conclusions

1. The prototype of the hybrid CAD is designed on the basis of presented software and algorithms of formation of technological operation structure, technological scheme and a machine layout.
2. The expert system of designing of technological machine layout is developed and it allows to increase the quality of the projects using two systems of structure searching: combinatorial or variant.
3. This software product is designed for automated designing of technological machine layout with the rules of layout that are determined on the basis of expert information, which includes the blocks of productive rules for selecting of sequence manufacturing of design and technological elements of a product, the flowsheet of machine formation, the rules of construction layout and special block of transformation which uses transformation rules of primary structures in new forms.

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