HIERARCHICAL STRUCTURES OF MACHINES FOR PACKING OF VISCOUS AND PLASTIC FOODSTUFF AND THEIR SYNTHESIS

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Abstract. *Continuous expansion of the range of viscous and plastic products, use of different types of a retail container, search of the functional modules and communications in between cause need of creation of effective methodology of the description and an assessment of structure of packing machines according to different characteristics. Application of hierarchical structure of packing machines allows to research options of their configuration, both at the level of units of the functional modules, and at the level of the machine in general. The methodology of SADT ("Structured Analysis & Design Technique") which allowed constructing three levels conceptual model of the machine is applied to effective analysis of structure packing machines: the functional, functional - structural and structural.*

Keywords: packing machine, viscous products, plastic products, hierarchical structure, SATD, model

I. Introduction

Machines for packing of viscous and plastic foodstuff in a retail container can be examined as multiposition technological machines of sequential action. They consist of sequentially connected functional modules and create the material, energetic and information (monitoring and control of operation) communications in between. The sequence of placement and number of these modules is defined by structure of execution of operations of packing and a number of elements (working line items) of which they consist [1, 2].

Development of packing machines (PM) is the complex task in which in difficult correlation tasks of synthesis, simulations, optimization intertwine.

II. Materials and methods

The problem of creation of effective methodology of the description and assessment of structure of packing machines by different criteria becomes more and more actual and requires the systems concept to questions of synthesis of machines.

Systems approach to reviewing of a packing machine as object of development provides creation of conceptual model that is such abstract model which displays structure of object and communication between its elements.

In case of creation of such models two aspects of the description of a packing machine are considered:

- the functional description which elements are the set of simple functions and a set of the relations in between which define the principles of functioning of a packing machine;
- the structural description which elements are the function models and communications in between which create configuration of a packing machine.

The functional description is more general as each technical function can be realized by different constructive options of the functional modules (FM). At the same time, each functional module realizes only that function for which it was created. Thus, the functional description precedes the structural [4].

The general algorithm of implementation of optimization synthesis of PM is given in fig. 1. Packing machines pertinently to apply SADT ("Structured Analysis & Design Technique" - methodology of structural analysis and design) methodology to execution of the analysis of structure which provides creation of three levels of conceptual model: functional (f-model), it is functional - structural (model fs-), structural (model s-) [3]. The description of SADT model is organized in the form of hierarchy of interdependent charts. The peak of this structure is the general description of system, and its basis consists of more detailed descriptions.

Each of the specified levels of creation of conceptual model assumes execution of a row of sequential stages.

At the first level there is a separation most of the PM important function, which is called as the

principal official function and, as a rule, corresponds primary purpose of creation of PM. After that it is necessary to realize decomposition of the PM, official function on the main and auxiliary.

At the second level selection of technical means of realization simple functions is carried out.

At the third level optimization of structure of PM in general is performed.

So, any useful effect of object expresses through the function executed by it. Its functional description represents f-model.

Creation of f - model - one of the main procedures of methodology of SADT, consisting in decomposition of the official function of the machine that is in a sequential output of functions of a certain level from functions previous, starting with principal, and establishment of communications in between (fig. 2). At the first level of decomposition the official function is considered result of combined action of several basic functions. Basic functions in turn share on auxiliary which their realize.

Decomposition of a certain function on levels f - models will be carried out until it doesn't break up to

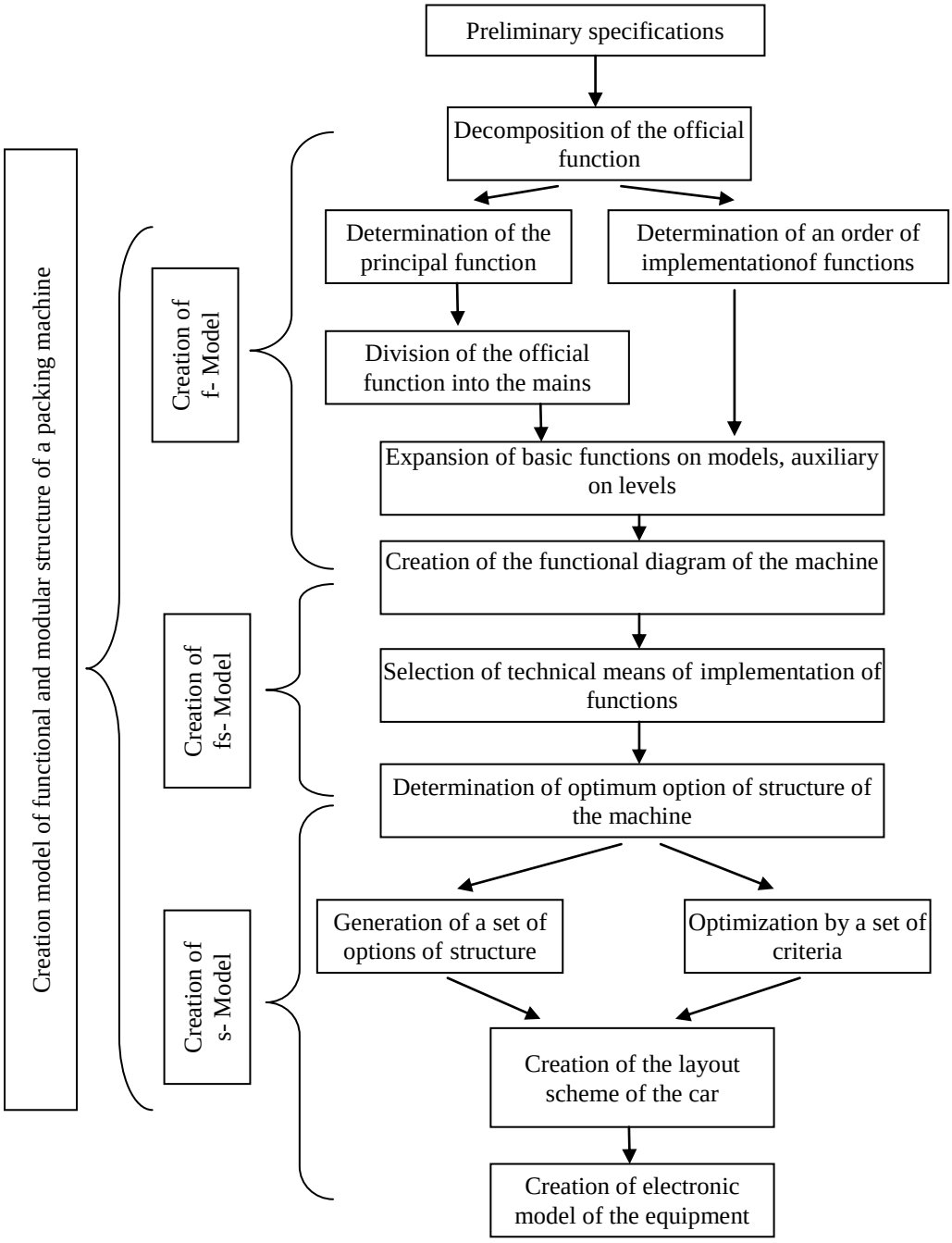

Fig.1. *Algorithm of implementation of optimum synthesis of PM*

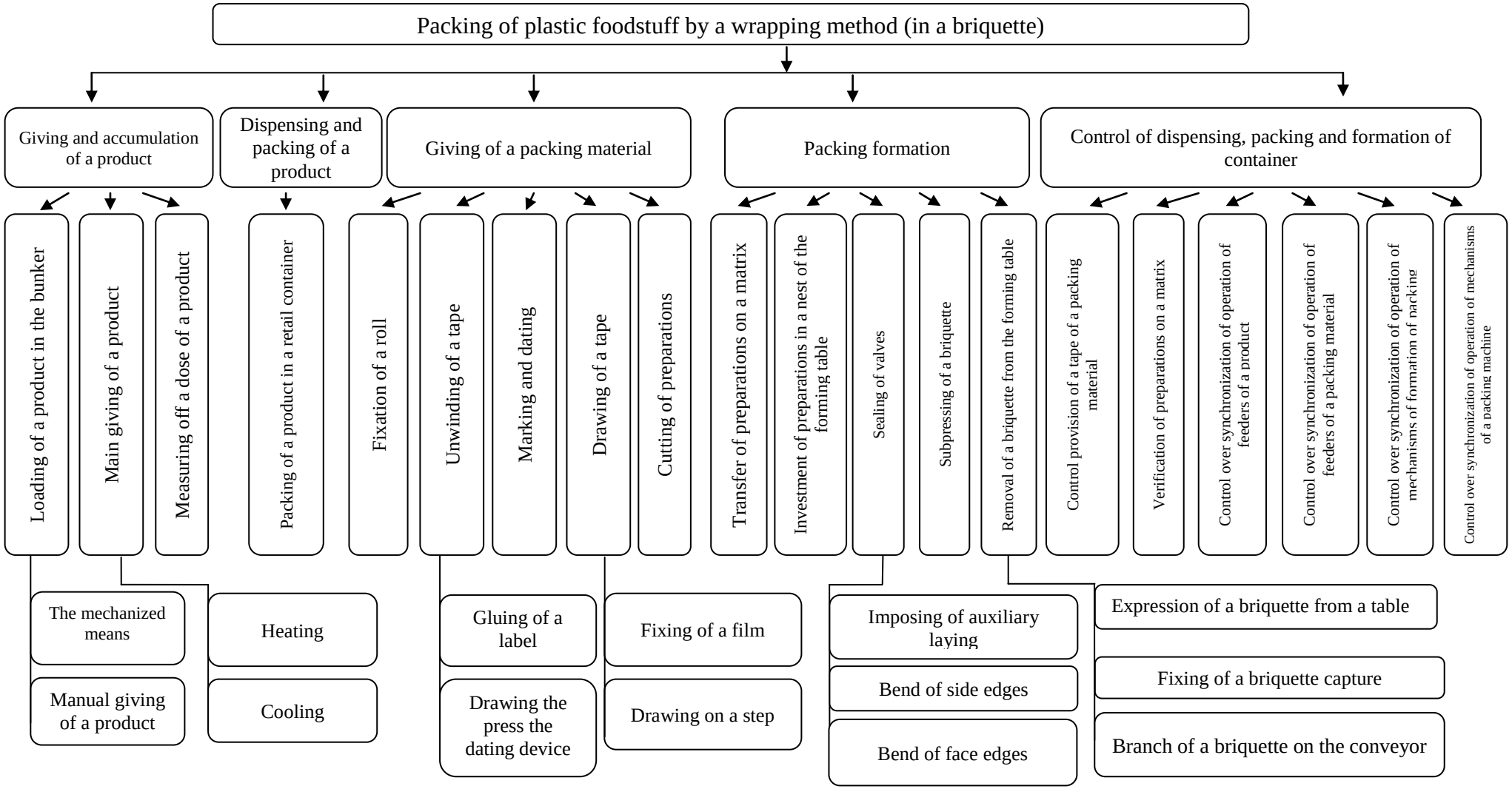

Fig. 2.*Scheme of decomposition of office function of the equipment for packing plastic food products by a wrapping method*.

functions for which implementation it won't become visible uses of a certain technical tool.

The SADT model, in turn, is a basis for creation of the intermediate fs-model presented in the form of the functional skeleton diagram of the machine on which appropriately arranged and interdependent functional modules are conditionally designated. In fig. 3 the generalized fs - machine model for packing

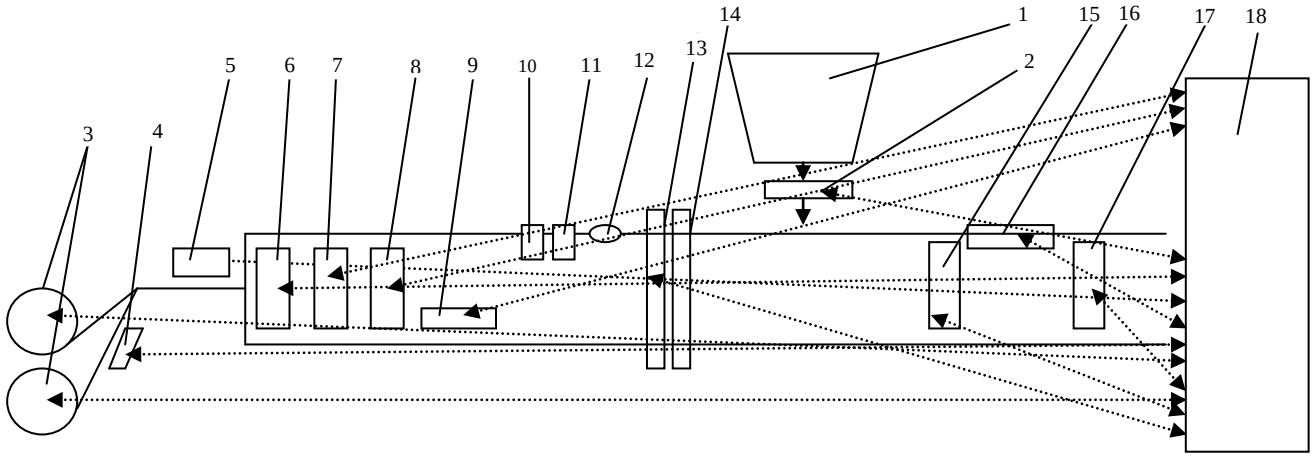

Fig. 3.*Generalized functionally - the block diagram (fs - model) cars for packing of viscous foodstuff in packages Doy-Pak: 1 - bunker; 2 - portioning device; 3 - feeder of a packing material; 4 - device of centering of a packing material; 5 - device of formation of a sleeve; 6 - first device of welding of a side seam; 7 - second device of welding of a side seam; 8 - the cooling device; 9 - the mechanism of fixing of a bottom of a package of that is Pak; 10 - device of drawing date; 11 - device of drawing notch; 12 - film broach device; 13,14 - device of cutting of packages; 15 - device of heating of a cross seam; 16 - the valve clip device between package walls; 17 - device of cooling of a package; 18 - control unit.*

of viscous foodstuff is provided to packets "Doy-Pak" which reflects all typical functional modules necessary for execution of technological operation of packing [2].

At this level in case of the description of functions use of such types of ratios is characteristic:

- a ratio between functions (to each other, one-to-many, many-to-many;
- the description of the material flows between elements of system (a ratio of communications on relocation of production, tare, packing materials, supportive packing applications);
- the description of control flows between elements of system (the description of causes and effect relationships between functions and logicians of their communications in time);
- the description of priorities between functions for certain types of production, packing materials, auxiliary packing materials used for packing.

Transition from the object, functional to the structural description that is creation of the PM s-model, is the most difficult design stage, it is explained by that to each function most often there correspond some standard sizes of FM therefore the main objective in case of creation of future machine design is separation of a rational set of the functional modules which will be able to be used for formation of its structure. For execution of this task it is necessary to realize optimization synthesis of configuration of the machine.

For simplification of the description of communications between the functional modules it is offered to use hierarchical approach to structure declaration of a packing machine. This approach assumes integration of modules on the functional sign in units of the functional modules (fig. 4).

It should be noted that in case of all the variety of arrangement solutions of machines for packing of foodstuff, each of them incorporates the dosing unit of the functional modules (UFM-1), the packing unit (UFM-2) and the additional unit of the functional modules (UFM-3). So the generalized hierarchical structure of the machine for packing of viscous foodstuff to soft package it is provided in fig. 5.

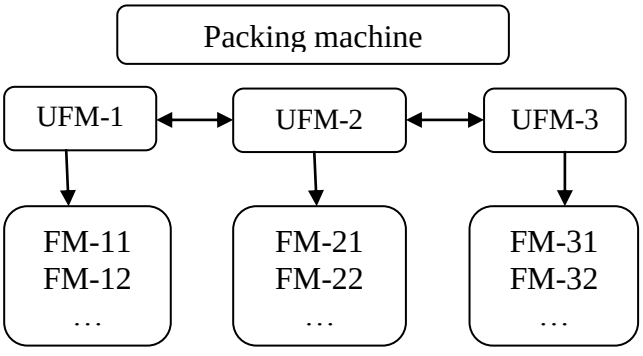

Fig. 4.*The general hierarchical concept of structure of a packing machine.*

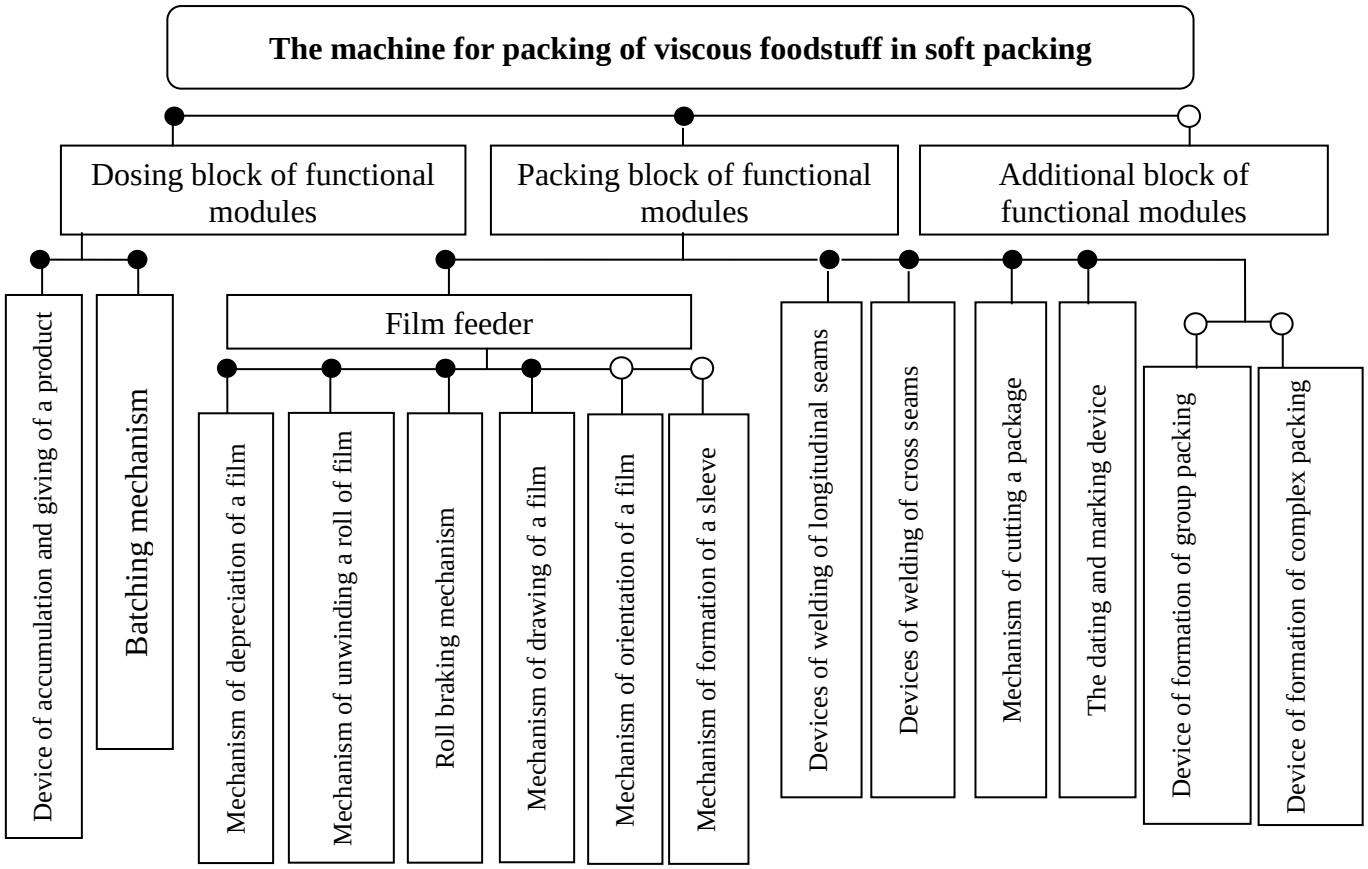

Fig.5.*Hierarchical representation of structure of a packing machine for viscous foodstuff:* ● *- tops are connected among themselves by the function «and»,* ○ *- tops are connected among themselves by the function «or».*

Application of hierarchical structure declaration of a packing machine allows to analyze more deeply nature of change of its configurations both at the level of UFM, and at the level of the machine, and also to simplify procedure of search optimum configurations.

In case of the solution of the discrete step-by-step task of optimization synthesis of structure of PM of any complexity and a choice of the most effective solution creation of a full set of admissible alternatives is required. Rules of generation of all possible options will be for this purpose set [5].

Generation of options of structure is carried out with the help:

- combinatorial methods which treat:
- morphological synthesis;
- synthesis on alternative trees;
- a generation method with the formal restriction of quantity of options of structure by means of the typical mathematical models normalized by GOST 14.416-83.

Morphological synthesis consists in finding and systematization of all possible options of combinations of FM among themselves by means of the morphological table. It can be applied on early blueprint stages, allows to find and systematize all possible methods of structural creation of PM. However, it is expedient to apply it only to PM with insignificant quantity of elements.

Synthesis on alternative trees differs in a method of formalization of structure declaration of object of design. The positive feature of a method is possibility of display of hierarchical creation of PM and communications between FM. However, graph images of options of structures beyond all bounds by quantity of the provided elements that doesn't allow providing them in the explicit form.

Creation with the formal restriction of quantity of options of structure of PM is carried out by means of standard mathematical models (MM).

Identical mathematical representation of structure of different PM is the cornerstone of creation of options of structure. In these models three data types about objecting of synthesis which create three sets are used: a set of elements - FM; set of signs or characteristics of MM; set of the relations between elements and signs or characteristics of MM.

By means of this method the following signs of distinctions between alternative options of structure of PM are considered:

- qualitative composition of elements, that are possible options of FM which form PM (F_E);

• number of FM, the forming PM (F_N);
• order FM in structure of PM (F_P).

If in case of generation of options of structure of PM in all options FM composition identical, $F_E = 1$, if the different - $F_E = 0$.

If in all options of structure there is identical a number of FM, $F_N = 1$, if different - that $F_N = 0$.

If the sequence of combining FM in structure of PM in all options is identical, $F_P = 1$, if different - $F_P = 0$.

The following design stage thus is the choice of the best of the received options that requires the analysis of all received options from the point of view of their compliance to a certain criterion of efficiency. Application of model of this kind considerably simplifies a choice of optimum option of structure as in case of its creation illogical combinations of FM are discarded directly.

Difference of the considered methods is that in case of morphological synthesis and synthesis on alternative trees all possible combinations of FM as a part of PM create, and when using standard mathematical models the quantity of possible options is reduced by a deviation of the impossible.

By development of the principles of combining of modules in the arrangement diagram of the machine that is implemented by means of software, it is necessary to create premises for the virtual design.

III. Conclusions

For research of machines was recommended systematic approach that involves the construction of a conceptual model which will reflect the structure of the object and the relationships between its elements. Expediently to apply SADT methodology that allows to analyze more deeply nature of change of structure of a packing machine to effective implementation of the analysis of structure of a packing machine and to simplify procedure of search of its optimum configuration. Application of hierarchical structure declaration of packing machines allows to research options of their configuration, both at the level of units of the functional modules, and at the level of the machine in general.

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